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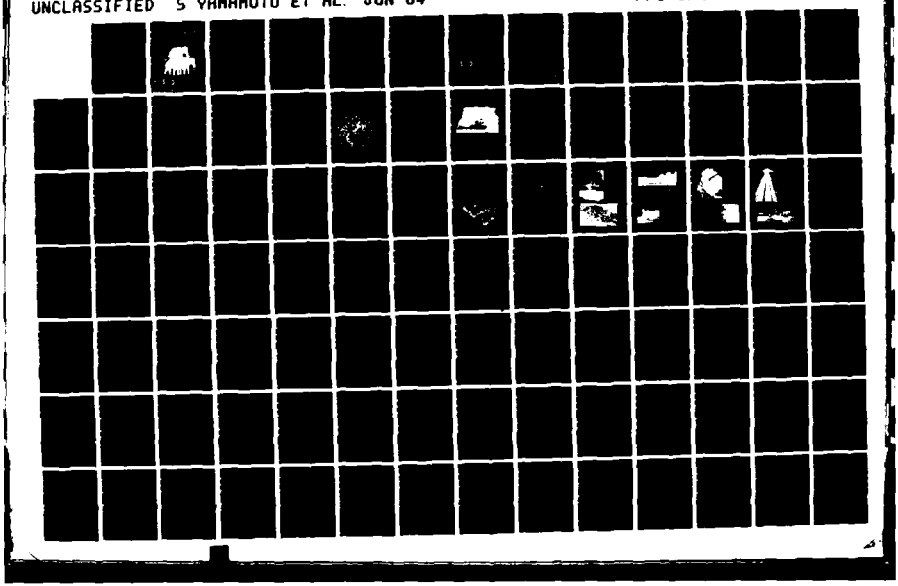

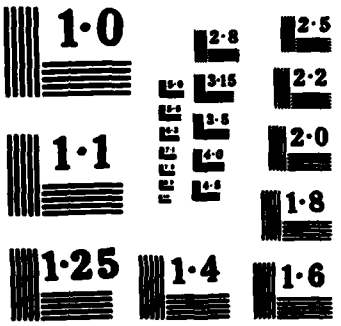
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APRIL TO JUNE 1984 VOL. 9, NO. 2

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SCIENTIFIC BULLETIN

DEPARTMENT OF THE NAVY OFFICE OF NAVAL RESEARCH FAR EAST
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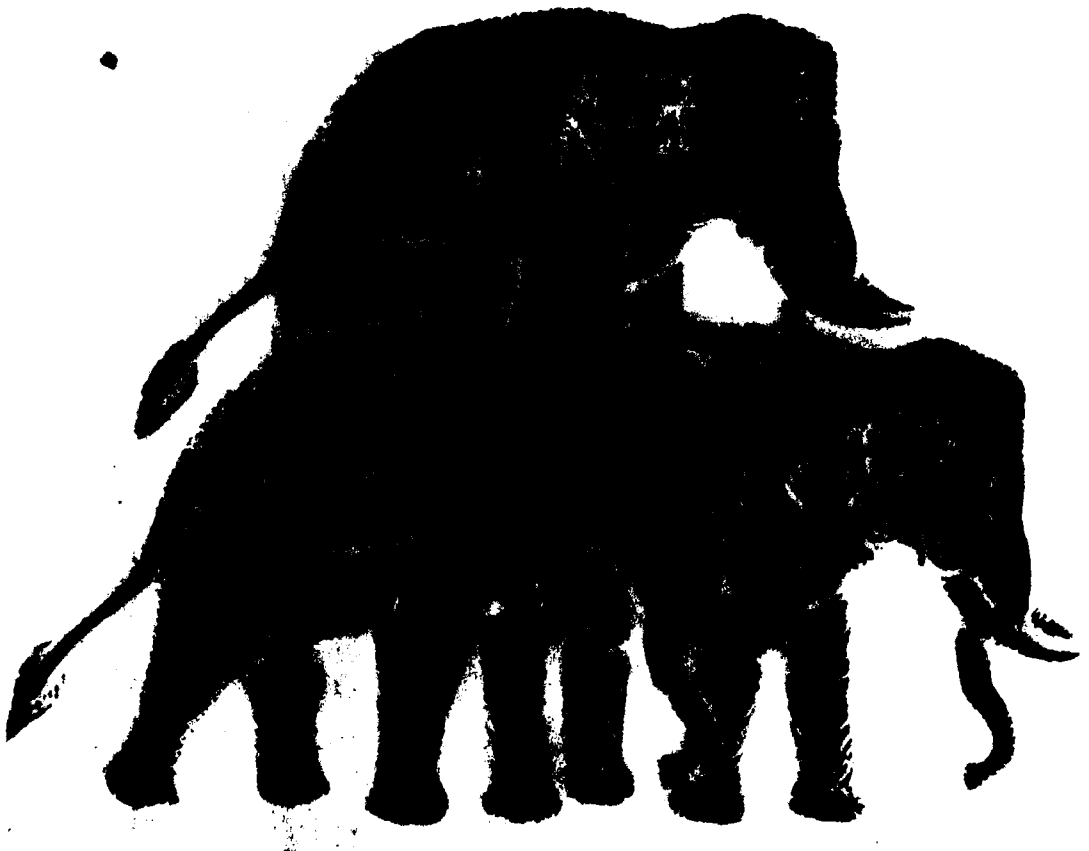

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ONRFE Vol 9, No 2	2. GOVT ACCESSION NO. A145-681	3. RECIPIENT'S CATALOG NUMBER
4. TITLE *(and Subtitle)* ONR FAR EAST SCIENTIFIC BULLETIN		5. TYPE OF REPORT & PERIOD COVERED 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Sachio Yamamoto, Director Mary Lou Moore, Editor		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research/Air Force Office of Scientific Research, Liaison Office Far East, APO San Francisco 96503		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS		12. REPORT DATE April-June 1984 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS*(if different from Controlling Office)*		15. SECURITY CLASS. *(of this report)* UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Aquaculture	Electronics
Fisheries development	Computers
Southeast Asia	Biotechnology
Marine sciences	New materials
Resources management	Newspaper articles

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Far East and

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S/N 0102-LF-014-6601

UNCLASSIFIED

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19. Key Words (continued)

Singapore
Reclamation
Shoreline
Reclamation technology
East Coast Reclamation Scheme
Malaysia
Physics
Universities
PUSPATI
Higher education
Fiber optics
Nippon Telegraph and Telephone Public Corporation
Electronics
Semiconductor physics
Engineering
Optics
Chemistry
Ceramics
Communications
Optoelectronic Industry and Technology Development Association (OITDA)
ORSTOM Research Center
New Caledonia
Marine science
Oceanography
Steelmaking
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Basic oxygen furnaces (BOF)
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Laser devices
Laser applications
Fujitsu, Ltd.
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Hard x-ray ring
High pressure research
MAX 80
Computational engineering mechanics
Beijing
Automated factories
Japan
Flexible Manufacturing System(FMS)
Biological sciences
Molecular science
Okazaki National Research Institutes
Institute for Basic Biology
Nonlinear optics
Supercomputers
Cray Research
Benchmarks

20. Abstract (continued)

and the Air Force Office of Scientific Research with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

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Sachio Yamamoto, a marine chemist, is currently the Director of ONR Far East. He is on leave from his position as head of the Marine Sciences Division at the Naval Ocean Systems Center in San Diego where, since 1969, he has served as a research chemist. Dr. Yamamoto received his Ph.D. in physical chemistry from Iowa State University in 1959, and his research interests are primarily in environmental sciences, trace metal analysis, gas solubility, and x-ray fluorescence analysis. Dr. Yamamoto is a member of the American Chemical Society.

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Cover: A temple rubbing depicting the Thai elephant. The elephant in Thailand is a symbol of Thai royalty. The most auspicious of Thai elephants were the so-called "white elephants." They are far from white although they are albinos; identification is made by the light-colored areas around the eyes, ears, and feet. Their presence in the royal stable was believed to ensure prosperity for the entire realm. On ceremonial occasions they were often adorned with 200 pounds of gold ornaments. Nowadays, white elephants are invariably presented to the King, though they are no longer so magnificently adored. (Temple rubbing contributed by Mary Lou Moore.)

MARINE SCIENCES IN SOUTHEAST ASIA

Sachio Yamamoto

Marine science laboratories in several Southeast Asian universities and institutions were visited by the author in January of 1984. This is a developing part of the world and research and development in the marine sciences is aimed at solving some of the practical needs of the people. Hence, emphasis is on aquaculture, fisheries development, and the development and management of resources. In the words of a scientist in the Philippines, "In developing nations we are concerned with putting food on the table and finding work for the people." There is, however, some fine research going on in some of the universities. Most of the researchers this writer met received their advanced degrees in the United States or Europe.

HONG KONG

- Environmental Protection Agency

The Environmental Protection Agency (EPA) of the government of Hong Kong is under the jurisdiction of the Secretary for Health and Welfare. It grew from an environmental protection advisor post which was established in 1975. Since 1978, it has grown from five persons to an organization of more than 100 people. The official function of EPA is to provide technical advise on environmental matters to the Secretary for Health and Welfare. Although they help draft regulations, they do not at the present time have any regulatory functions proscribed by ordinances. However, this is soon to change for they will assume regulatory functions in the area of noise control. There are four groups in EPA:

- Air Quality and Hazards Assessment Group,
- Noise and Vibration Group,
- Water Quality Group, and
- Waste Management Planning Group.

The Water Quality Group, which this writer visited, carries out three functions: legislation and policy, monitoring, and planning. This group conducts several monitoring programs in the waters surrounding Hong Kong and in the inland rivers. The waters around Hong Kong are divided into three subregions:

- Victoria Harbor which is under stress due to sewage and industrial wastes,
- Western Waters which is affected by the outflow of the Pearl River, and
- Southern and Eastern Waters which is a relatively clean area (see Figure 1).

Three of the major monitoring programs are in the last subregion.

The Port Shelter and Rocky Harbor areas are rural in nature with little urban growth and are used primarily for recreation. However, the region is under increasing threat from development and the purpose of the monitoring program is to obtain baseline information.

Tolo Harbor and Channel is a region facing rapid growth; the population is expected to expand from the present 60 thousand to one million by the mid-1990s. Biweekly sampling at three depths takes place at 15 stations. The results are fed into a

mathematical model to predict future water conditions arising from development. Components of the model are shown in Figure 2.

There are no formal research progams at EPA. However, Dr. David J. H. Phillips, who has for some years conducted studies on trace metals in marine organisms, is continuing work in this area. He is studying the levels of arsenic, cadmium, copper, lead, mercury, and zinc in samples of the Pacific oyster, *Crassostrea gigas*, taken from Deep Bay in the northwest New Territories of Hong Kong where they are cultured.

- University of Hong Kong

The University of Hong Kong was founded in 1911. Its enrollment is approximately 7000 at present but is expected to grow to about 10,000 by 1990. There are five faculties: arts, science, medicine, engineering, and social sciences; and three schools: architecture, law, and education. The Faculty of Science includes the departments of botany, chemistry, mathematics, physics, and zoology. Although the university is undergoing rapid expansion, it is forming new faculties rather than expanding existing ones. Hence, most of the science departments have not grown over the last several years.

Marine science research is being conducted in the Departments of Botany and Zoology. Five of the 17 staff members are engaged in marine research and together they run a group of 16 part- or full-time research students. Marine research in the Department of Zoology centers around Professor Brian S. Morton, a marine biologist. His studies in the recent past include:

- biofouling of mariculture cages in Hong Kong,
- aspects of marine fouling and antifouling in Victoria Harbor,
- ecology of marine woodborers in the coastal waters of Hong Kong, and
- ecology of coastal reclamation in Hong Kong.

Among his current studies is the effect of thermal pollution from power plant discharges.

In addition to his teaching and research activities, Professor Morton has organized research workshops. These workshops are held at Wu Kai Sha on Tolo Bay. Foreign scientists are invited to spend two-three weeks on a research project, the results of which are published in a workshop proceedings. To date three workshops have been held. The first was entitled, "Malacofauna of Hong Kong and Southern China," held from 23 March-8 April 1977 at which 18 people participated and the second was called "Marine Flora and Fauna of Hong Kong and Southern China," held 18 April-10 May 1980 with 42 participants. The third was held in the fall of 1983 and had 60 participants. These workshops provide a means for rapidly acquiring a large amount of information on the ecology of Hong Kong.

Professor Morton was also instrumental in founding the Marine Biological Association of Hong Kong in 1982. The association is publishing a new journal, *Asian Marine Biology*, the first issue of which will be published in 1984.

At the university there is a proposal currently under consideration to establish a Marine Science Center at Cape D'Aguilar on the southeast side of Hong Kong Island. The center is intended to be a postgraduate and postdoctoral research station.

Further information regarding the marine biology workshops and the journal, *Asian Marine Biology*, can be obtained from:

Professor Brian Morton
Department of Zoology
The University of Hong Kong
Pokfulum Road
Hong Kong

- Fisheries Research Station, Hong Kong

The Fisheries Research Station is part of the Fisheries Research division in the Department of Agriculture and Fisheries. The Division is divided into the following groups: Marine Resources Section, Aquaculture Section, Marine Pollution Section, and Hydrography Unit (the last provides support to the sections). The primary function of the Marine Resources Section is to assess fish stock in the South China Sea. In the past, environmental monitoring used to be conducted by the Marine Pollution Section, but that function has been transferred to the Environmental Protection Agency. This group is currently studying red tides and their effect on mariculture and the effect of reclamation and industrial projects on the environment.

THAILAND

- Chulalongkorn University, Bangkok

Chulalongkorn University was founded in 1917 and is the oldest university in Thailand. There are 14 faculties:

- arts,
- science,
- architecture,
- commerce and accountancy,
- political science,
- economics,
- education,
- engineering,
- medicine,
- veterinary science,
- dentistry,
- communications art,
- law, and
- pharmaceutical science.

The Faculty of Science consists of 12 departments:

- biochemistry,
- biology,
- botany,
- chemical technology,
- chemistry,
- general science,
- geology,
- marine science,
- materials science,
- mathematics,
- physics, and
- microbiology.

The total number of students in this faculty is approximately 2000.

The Marine Science Department has a staff of 15 and about 30 undergraduate and 30 graduate students (Masters of Science candidates) majoring in marine science. Of the staff, four specialize in marine chemistry, seven in marine biology or ecology, two in ocean engineering, and one in physical oceanography. In chemistry, Dr. Manuwadi Hungspreug has studied trace metals in seawater, sediment, and organisms for some years. She is currently studying trace metal composition and accumulation rates of sediments of the Upper Gulf of Thailand. This work is being done in conjunction with Dr. Herbert L. Windom of the Skidaway Institute of Oceanography. She is also studying heavy metals and polycyclic hydrocarbons in benthic organisms of the Upper Gulf. Dr. Gullaya Wattayakorn, an organic geochemist, has studied DDT residues in the marine environment and her current interest is polycyclic aromatic hydrocarbons. Among the marine biologists, Professor Tweskudi Piyakarnchana is studying organic tin poisoning of marine organisms and eutrophication and Dr. Piamsak Menasveta is studying the breeding and culturing of the freshwater shrimp *Macrobrachium rosenbergii* and the marine shrimp *Penaeus monodon* and the diseases of serpent fish.

The department has a marine research and training station on Sichang Island in the Bight of Bangkok. The director of the station is Dr. Menasveta.

MALAYSIA

- University of Science, Malaysia, Penang

A general description of the University of Science, Malaysia is presented by Dr. L. H. Fisher (see this *Bulletin*). Marine science studies are centered in the School of Biological Sciences. The school has a staff of 50 and offers courses in physical and chemical oceanography, ecology, and environmental pollution. Some of the current research projects in marine sciences (and their principal investigators) are:

- the reproductive physiology of fishes with special emphasis on ovarian maturation and artificial spawning	Dr. Khoo Khay Huat
- profile of a mangrove estuary	Dr. Ong Jin Eong Dr. Gong Wooi Khoon Dr. Wong Chee Hoong
- study of organic productivity and mineral cycling in mangrove forests	Dr. Ong Jin Eong Dr. Gong Wooi Khoon Dr. Wong Chee Hoong
- studies on the prospects and and introduction of culture of local molluscs as a protein source in Malaysia	Dr. P.M. Sivalingam
- induced spawning of estuary grouper, *Epinephelus salmoides*	Dr. Lai Hoi Chaw

- fate and effect of naturally and chemically dispersed oil in the tropical marine environment	Dr. Lai Hoi Chaw, *et al.*
- induced spawning and larval culture of the cockel *Anadara granosa*	Dr. Wong Tat Meng
- fish stock identification and assessment	Dr. Eddy S.P. Tan, *et al.*
- biodegradation of crude oil in the Sabah and Sarawak marine environment	Dr. Nor Muhammad Mahadi, *et al.*
- aspects of marine microbial pollution in Penang	Dr. Leong Yueh Kwong Dr. Wong See Yong
- the role of marine blue-green alga in the nitrogen economy around Muka Head, Penang	Dr. Tan Sai Tee Dr. I.G. Caunter
- biology of coral reefs	Dr. Ong Jin Eong Miss Helen E. Newman

The university has a marine science station on the northern tip of Penang Island. It is situated on five acres of land and, at present, is accessible only by boat. The station has large outdoor seawater tanks for breeding studies; a three-story laboratory building with a large wet laboratory, aquaria room, teaching laboratory and classrooms; and accommodations for up to 200 people which are used during the training sessions. The station is used mainly for training and is, otherwise, greatly underutilized.

- Fisheries Research Intitute, Malaysia

The Fisheries Research Institute is part of the Department of Fisheries in the Ministry of Agriculture of Malaysia and is located in Penang. It currently has a staff of 386 of whom 68 are scientists. There are three sections: aquaculture, fisheries resources, and aquatic environment. Environmental monitoring is a function of the aquatic environment section which is headed by Dr. Alexander A. Jothy. The area of concern of their monitoring program is the coastal waters of Malaysia, but at the present time their efforts are concentrated in the coastal areas in the northern part of the Straits of Malacca. Among their current projects are:

- monitoring of pollutants (oil, heavy metals, etc.),
- toxicity screening of oil dispersants,
- monitoring of heavy metals, pesticides and
- PCB's in fish and shellfish.

The institute has five vessels (one steel-hulled and four wooden-hulled) for use in their programs. The steel-hulled vessel, the KK *Mersuji* is 23 meters long and has a gross tonnage of 97 tons and was received from the Japan International Cooperation Agency (Figure 3).

PHILIPPINES

- Marine Science Center, University of the Philippines

The Marine Science Center of the University of the Philippines is located on the Diliman campus in Quezon City, Metro Manila. The university has an enrollment of 31,000 (6000 graduate students). It is organized somewhat like the University of California and has four semiautonomous campuses: Diliman, the largest with 20,000 students; Manila, the original campus which is now the university's medical and health sciences campus; Los Banos, which is the agricultural campus; and Visayas, the newest campus which is still undergoing construction. In addition, there are regional units which are four-year liberal arts colleges in Baguio City, Angeles City, and San Fernando; Pampanga in Luzon and Cebu City and Tacloban City in the Visayas.

The center was established in 1974 as a research organization and serves as the coordinating point for marine science research at the university. Its program is designed to complement that of the College of Fisheries of the Visayas campus. A number of the staff have teaching duties in the College of Arts and Sciences which has responsibility for marine science courses. The center has a staff of 70 of whom 60 comprise the research staff (including research assistants). Its director is Dr. Edgardo D. Gomez, a marine biologist, who received his doctorate from the Scripps Institution of Oceanography.

Research emphasis of the center is in marine biology and biochemistry. Its current research programs and the principal investigators are:

. Marine Biology

- monitoring of coral reefs	Dr. Edgardo D. Gomez
- larval and juvenile biology of *Portmus pelagicus*	Emmanuel Olympia
- taxonomy and distribution of Philippine porifera	Mai Lopez
- biological and ecological studies of spiny lobsters	Dr. Edgardo D. Gomez
- development of mass sporulation technology for the culture of *Acanthopora specifira*	Dr. Gavino C. Trono
- establishement and maintenance of a type culture collection of marine bacteria, fungi, and yeasts	Dr. Flordeliz Uyenco Professor Luisa Saniel
- the reproductive biology and ecology of agarophyte *Gelidiella acerosa*	Edna G. Foretes
- management studies on the natural stocks of *Acanthopora specifira*	Dr. Gavino Trono
- study on the behavior, growth, and feeding habits of Philippine commercial holothurians	Lydia Leohardo

- primary productivity and nutrient studies in relation to oyster biology	Fil S. Jacinto
- seaweed and invertebrate resources of Lingayen Gulf	Dr. Gavino C. Trono Mai Lopez
- reproductive cycle of *Diadema setosum*	Dr. Edgardo D. Gomez
- studies on the natural recolonization of damaged reefs, and their rehabilitation by coral transplantation	Ms. Helen Yap
- studies of the relationship between age and amount of recoverable carageen in *Eucheuma*	Dr. Gavino Trono
- mangrove fishes of Pagbilao, Quezon with notes on their abundance and seasonality	Dr. Reynaldo de la Paz
- taxonomy and production ecology of Philippine seagrasses	Professor Miguel Fortes
- environmental studies in Tabangao, Batangas	Dr. Gavino Trono
- reproductive biology of bivalve molluscs (scallops)	Mai Lopez
- study on the reproductive biology of *Strombus luhuanus* at a selected intertidal reef area	Porfirio Alino

. Marine Chemistry

- chemistry of seaweed extracts	Ms. Evelina Laserna
- physicochemical analysis of marine algal polysaccharides	Ms. Evelina Laserna
- ecology and chemistry of Philippine soft corals	Dr. Gloria J.B. Cajipe
- fish toxicants from the mangrove plants *Aegiceras corniculatum, Derris trifoliata, Excoecaria agallocha and Heritiera littoralis*	Dr. Armando de la Cruz Dr. D. Howard Miles (Mississippi State University) Dr. Edgardo D. Gomez Dr. Gloria Cajipe

- product formulation utilizing seaweeds and seaweed extracts in horticulture	Nemesio Montano

. Marine Biochemistry

- isolation and characterization of phosphsolipase A_2 from *Conus textile* venoms	Professor Milagros Leano Professor Angelita Reyes
- species identification and classification of fishes and other aquatic products thru classical and other characterization techniques	Julie Macaranas
- collaborative project between SEAFDEC and UPMSC on genetic variation in milkfish	Julie Macaranas
- studies on the genetic characteristics of food fishes using electrophoretic markers	Julie Macaranas

For additional information on the Marine Science Center see Dr. F. A. Richards' article [*Scientific Bulletin, 3, (3), 26 (1978)*].

- Bureau of Fisheries and Aquatic Resources, Ministry of Natural Resources

The Bureau of Fisheries and Aquatic Resources started as the Division of Fisheries in the Bureau of Science in 1907. After a few reorganizations over the years, it was, in 1974, given its present name and placed under the Ministry of Natural Resources. The bureau has 14 divisions, one of which is the Fisheries Research Division. It is headed by Dr. Inocencio A. Ronquillo and is located in Quezon City, Metro Manila. The primary concerns of the division are with the state, potential, and management of living natural resources. *Their projects include:*

- study of fishes (behavior, breeding, etc.) in the Cagayan River,
- management strategies for marine parks,
- artificial reef development using indigenous materials and implementing these methods as community projects,
- macrolevel survey of the coral reefs in the sea west of Palawan Island,
- study of tropical aquarium fish.

The division has its own research vessel, the 44-meter R/V *Red Tide*. It is mainly used in fish stock surveys.

- International Center for Living Aquatic Resources Management (ICLARM)

ICLARM is an autonomous, nonprofit, and nongovernmental organization which was established in 1975 with support from the Rockefeller Foundation. It was initially

located at the University of Hawaii and, in 1977, was incorporated in the Philippines. The purpose of ICLARM is to improve conditions of the rural poor in developing nations by the development of aquaculture and fisheries management techniques. The organization is designed to function in a manner similar to the International Agriculture Research Centers, except that it has no research laboratory of its own. Instead it conducts research in cooperation with existing institutions in developing countries. There are currently seven scientists in Manila, six in the field, and 20 support personnel.

The research programs are in three categories: aquaculture, resource development and management, and traditional fisheries. Emphasis in the aquaculture program is on commercialization of hatcheries, fry and fingerling supply, etc., of lower priced species such as tilapea; systems for integrating aquaculture with agriculture; economic analysis of aquaculture systems; and stock improvement through genetic studies. The resources development and stock assessment project is mainly concerned with stock assessment methods for the tropics where methods for the temperate zone are not always applicable. The traditional fisheries program is primarily a socioeconomic study of the problems facing the small-scale fishermen who predominate in developing nations.

Further information can be obtained from:

Dr. Richard A. Neal
Director General
International Center for Living
Aquatic Resources Management
MCC P. O. Box 1501
Makati, Metro Manila
Philippines

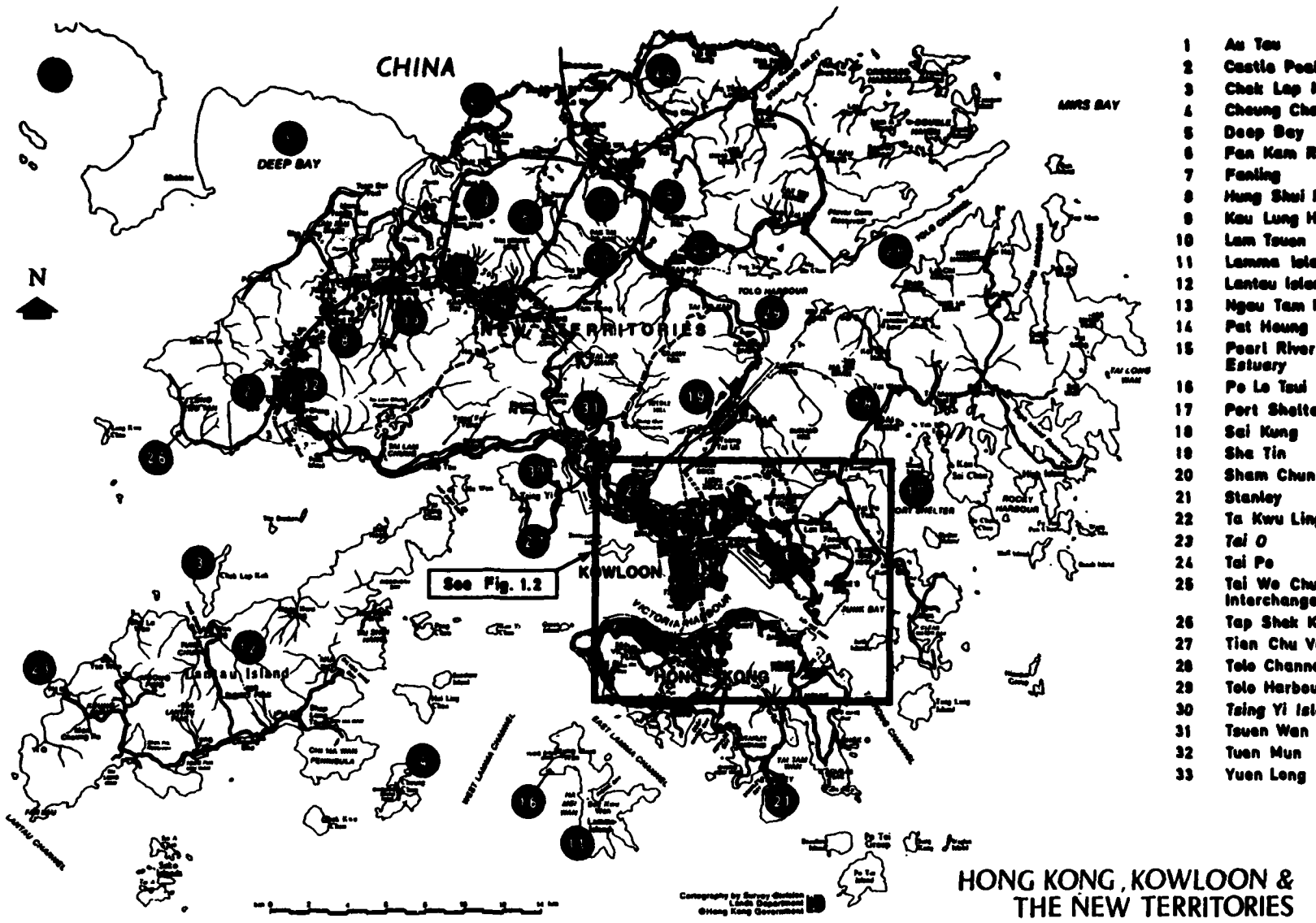

Figure 1. Hong Kong, Kowloon and the New Territories

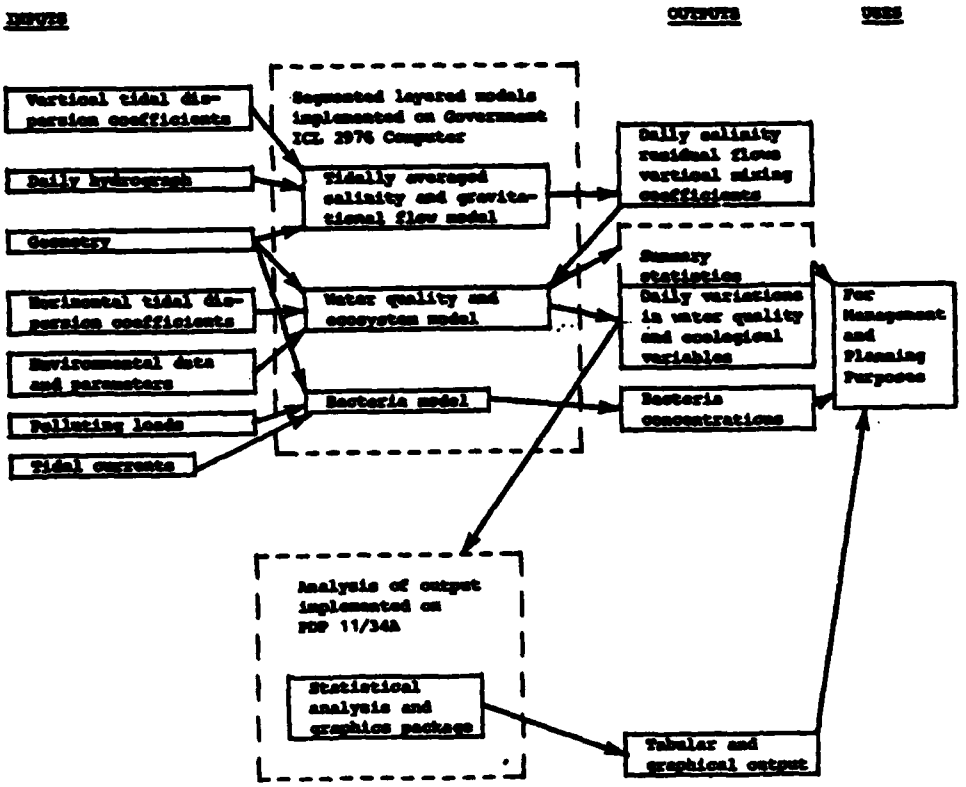

Figure 2. Components of Tolo mathematical model used by Environmental Protection Agency, Hong Kong

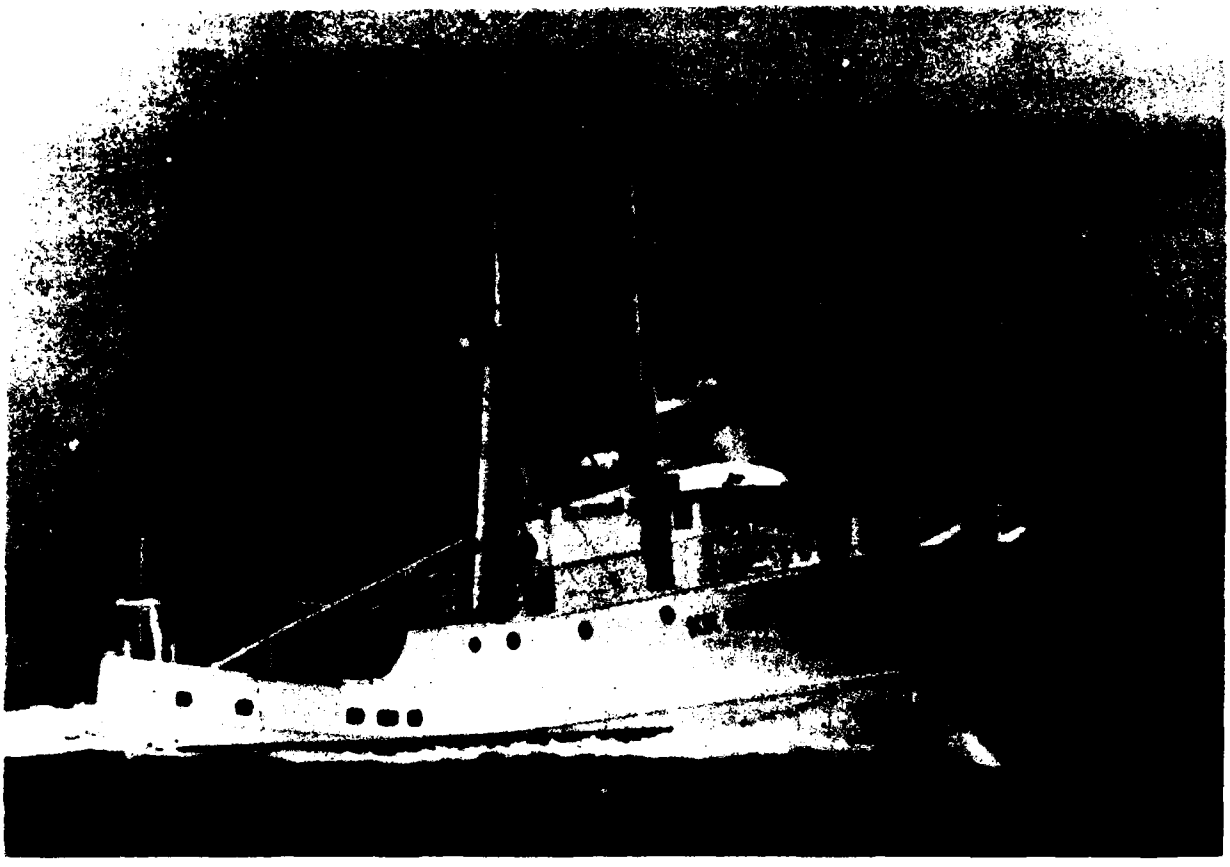

Figure 3. Research vessel, KK *Mersuji*, of Fisheries Research Institute of Malaysia

JAPANESE SCIENCE AND TECHNOLOGY ACTIVITIES IN 1983 AS VIEWED FROM NEWSPAPER ARTICLES

Seikoh Sakiyama and Sachio Yamamoto

INTRODUCTION

After the oil "shokku" of 1973, Japan de-emphasized energy- and resource-intensive industries in favor of what the Japanese call knowledge-intensive industries. Their phenomenal economic growth since the end of World War II was based upon industries such as textiles, steel, chemicals, and shipbuilding. Now the emphasis is on fields such as electronics, computers, biotechnology, and new materials. This change in emphasis has been accompanied by a marked increase in science and technology activity in Japan.

According to the *Survey Report on Research and Development* published in 1983 by the Statistics Bureau of the Prime Minister's Office, Japan's R&D expenditures for science and technology in JFY1982 totaled 6,529 billion yen ($29.68 billion, $1 = Y220). This represented a 9.1% increase over the previous fiscal year and makes it the second largest in the free world. Of this amount 25.5% came from government and 74.4% from the private sector. Breakdown by type of research is 18.2% basic, 27.1% applied, and 54.7% developmental. The proportion devoted to basic research is increasing in Japan; in JFY1980 it was only 14.8%. When classified by type of expenditure, we find that wages and salaries were 46.9%, materials 15.6%, tangible fixed assets 17.8% and others 19.7%. As of 1 April 1981 there were 406,000 researchers in Japan, up 3.4% from the previous year. Of this number, 201,100 were in industry, up 4.2%; 170,100 in universities, up 4.2%; and 34,800 in research institutes, down 4.4%.

A report of the Bank of Japan shows that the export of Japanese technology (based on receipts from royalties) increased 38% in JFY1981 to 118.4 billion yen ($538.0 million). while imports increased 16% to 377.2 billion yen ($1.714 billion).

The number of patent applications in Japan rose 14.1% to 218,262 in JFY1981 (utility model applications were up 3.8% to 198,978). The largest number of patents applied for were in (JFY1980):

- electrical engineering	41,693	22.0%
- physics	41,123	21.7%
- processing, operations, and transportation	37,711	20.0%

In addition, the number of patent applications by Japanese nationals in foreign countries numbered 35,254 in JFY1980, up 11.0% from the previous year.

This increased R&D activity has resulted in a great rise in the number of research papers published in Japan. The number of Japanese papers abstracted in *Chemical Abstracts* in 1979 ranked third in the world behind the United States and the Soviet Union. It is estimated that more than 4.5 million papers, reports, articles and conference documents are produced annually. Along with the proliferation of literature, data bases and on-line retrieval services are being developed by government and private organizations. Notable among these are the Japan Information Center for Science and Technology (JICST) and the Japan Patent Information Center (JAPATIC).

NEWSPAPERS AS SOURCES OF INFORMATION

There are numerous sources of information by which trends in Japanese science and technlogy can be ascertained. Among them are newspapers. In Japan there are two daily newspapers, *Nikkan Kogyo Shinbun* and *Nikkei Sangyo Shinbun*, with circulations of 544,000 and 202,000, respectively; and a weekly, *Kagaku Shinbun* with a circulation of 110,000 which report science and technology news. The former two primarily report news about industrial technology. Their articles mainly contain news of high technology products, new processes, research and development results, science and technology policy, and some economic and business news related to technology. The latter reports news about science and technology, but with emphasis on chemistry and the life sciences. Japanese newspapers are much less voluminous than American papers and their articles are generally shorter and less comprehensive than those that appear in U.S. newspapers. Nevertheless, it was thought that research and development activity and trends in the various fields could be discerned from the articles and the numbers of articles in each field. Such trends are, of course, summarized in various publications such as the government white papers, but they tend to be dated.

In this report, Japanese R&D activity in various fields in 1983 as discerned from newspapers is presented. The three newspapers mentioned above and a general daily newspaper, *Asahi Shinbun*, with a circulation of 7,477,000, were reviewed daily. There were approximately 70,000 articles of which about 2600 were selected for this survey. These were articles about new projects being started, new directions in science and technology, announcements of breakthroughs, R&D results and assessments or evaluations of science and technology.

RESEARCH AND DEVELOPMENT ACTIVITY

The results of the survey are summarized in Table I. Ninety percent of the articles can be categorized very broadly into electronics and natural resources.

- Electronics

. Computer technology (38.2%).

This is clearly the most active field. In this category 20.6% dealt with computer systems, that is, incorporation of peripherals including VTRs and copying machines into computer systems, robotics, and sensors (sensors were included in this category because most are used in conjunction with microprocessors; they could also have been included in the materials category since many involve development or applications of new materials). Activity in software (9.2%) were mainly in the area of office and factory automation, kanji-kana readers, speech recognition, and artificial intelligence. Semiconductors (8.4%) was also included in this category. Emphasis was on semiconductor materials and production equipment.

. Communication technology (13.8%)

In this area telecommunications (10.5%) is a rapidly growing field, stimulated by an increase in data communication requirements, data banks, electronic mail, and facsimile. Optical communication (3.3%) is centered mainly on optical cables, devices, and materials. In addition, optical discs are being developed for use in office automation systems.

- Natural Resources

We have included in this category all fields that deal with energy, materials, and biology. Although there is considerable research activity in the basic natural sciences such as chemistry, physics, and biology, these subjects do not often appear in newspapers.

. Energy (27.4%)

In this group, energy-related articles appeared most frequently. This is a reflection of the fact that Japan has virtually no energy resources of its own. In this category, the most active area is energy conservation (12.4%), including recycling of waste energy and materials, followed by development of natural energy sources, of which by far the most active is the development of solar cells, in general and amorphous silicon cells in particular. Development of alternative energy sources (5.1%) dealt largely with nuclear power development, biomass conversion, hydrogen storage materials, fuel cells, and coal liquefaction.

. Materials (14.1%)

Among new materials (7.4%), the greatest emphasis was on ceramics. Organic materials lead the traditional materials development (6.7%) followed by iron and steel, magnetic materials, and glass. There was also a fair amount of activity in the development of methods for obtaining high purity water for use in the electronics industry.

. Biotechnology (3.8%)

Japan has an old and highly developed fermentation industry. About four years ago the government began to emphasize research and development in biotechnology. Articles in 1983 primarily concerned DNA, bioreactors, biosensors, and breeding. There were very few articles pertaining to medicine (1.1%) and these dealt mostly with health and environmental topics.

Other areas covered include space and aeronautics, marine sciences, and construction.

In Table II the 62 news subjects are listed in the order of decreasing number of articles. The first 13 subjects account for 1372, or half, of the articles surveyed. Of these, 761 articles were related to electronics (computers and peripherals, sensors, semiconductor chips, office automation, VTRs, and data and satellite communications), 451 to energy (solar cells, heat and fuel conservation, and batteries), and 140 to materials (ceramics).

Clearly, electronics and energy-related fields are the most active in Japan. The former bears out Japan's move away from traditional industries into so-called high technology industries, which we mentioned earlier. The emphasis in this area is on the application of electronic systems and devices in widely divergent areas. The tremendous activity in the energy area reflects the fact that Japan must import virtually all of her energy resources. Their energy research and development efforts are directed towards energy conservation and reduction of energy consumption in their industrial processes. In addition, the diminishing and uncertain supply of energy resources forces Japan to develop some degree of energy independence by development of alternative sources. Finally, the high number of articles dealing with sensors shows that Japan is one of the most active nations in the research and development of sensors.

TABLE I

A breakdown of newspaper articles on science and technology in Japan during 1983 by subject. There were 2638 articles surveyed, the number of articles are in parenthesis.

ELECTRONICS 52.0%

- Computers 38.2%

. Computer Systems 20.6%

Computer and peripherals (152)
Sensors (140)
Robotics (95)
VTR (60)
CAD/CAM (22)
Word processing (20)
Copy machines (17)
Others (37)

. Software 9.2%

Office automation (72)
Factory automation (47)
Fifth generation computers (20)
Artificial intelligence (20)
Speech recognition (12)
Software patents (12)
Telecommunication (10)
CAD/CAM (10)
Computer learning (5)
Others (35)

. Semiconductors 8.4%

Semiconductor chips (120)
Semiconductor materials (50)
Production equipment for semiconductors (30)
Others (22)

- Communication 13.8%

. Telecommunications 10.5%

Data communication (65)
Satellite communications (57)
Information network system (50)
Data bases (47)
Telephone systems (27)
Electronic mail (15)
Facsimile (10)
Others (5)

. Optical communications 3.3%

Devices (22)
System (20)
Cable (12)
Optical discs (12)
Materials (5)
Others (17)

NATURAL RESOURCES 45.3%

- Energy 27.4%

. Energy Conservation 12.4%

Heat (122)
Fuel (97)
Materials (37)
Electricity (30)
Others (42)

. Natural energy 9.9%

Solar cell (135)
Energy storage and distribution systems (97)
Wave energy (12)
Geothermal energy (7)
Hydroelectric energy (2)
Snow (2)

. Alternative energy 5.1

Nuclear energy (37)
Biomass (37)
Hydrogen absorption alloy (30)
Fuel cells (15)
Cool liquefaction (15)

- Materials 14.1%

. New Materials 7.4%

Ceramics (140)
Amorphous alloys (15)
Composite materials (7)
Others (32)

. "Traditional" Materials 6.7%

Organic materials (52)
Iron and steel (17)
Magnetic materials (15)

Glass (12)
High Purity Water (12)
Others (70)

- Biotechnology 3.8%

. Bioengineering 2.7%

DNA 930)
Breeding (30)
Bioreactors (5)
Biosensors (5)

. Medicine 1.1%

Medical science (15)
Environment (15)

- OTHERS 2.7%

TABLE II

NEWSPAPER ARTICLES IN DECREASING NUMERICAL ORDER

Subject	Number of articles
Computer and peripherals	152
Sensors	140
Ceramics	140
Solar cell	135
Heat conservation	122
Semiconductor chips	120
Fuel conservation	97
Batteries	97
Robotics	95
Office automation	72
Data communication	65
VTR	60
Satellite communication	57
Organic materials	52
Information network system	50
Semiconductor materials	50
Factory automation	47
Data bases	47
Materials conservation	37
Nuclear energy	37
Biomass	37
Breeding	30
Electrical energy conservation	30
DNA	30
Hydrogen absorption alloys	30
Production equipment for semiconductors	30
Telephone systems	27
Optical devices	22
CAD/CAM systems	22
Optical systems	20
Fifth generation computer	20
Word processors	20
Artificial intelligence	20
Iron and steel	17
Copying machines	17
Magnetic materials	15
Amorphous alloys	15
Electronic mail	15
Coal liquefaction	15
Fuel cells	15
Environment	15
Medical science	15
Optical cables	12
Wind power	12
Glass	12

Speech recognition	12
High purity water	12
Optical discs	12
Patents	12
Facsimile	10
CAD/CAM software	10
Telecommunication	10
Composite materials	7
Geothermal power	7
Wave activated power	5
Biosensors	5
Bioreactors	5
Optical materials	5
Computer-aided learning	5
Snow power	2
Hydroelectric energy	2
Others	331

RECLAMATION AND THE REPUBLIC OF SINGAPORE

H. J. Walker

Although there may be some correlation between a country's size and its importance in the world today, exceptions are numerous. Singapore is certainly one of the most conspicuous exceptions. No larger than a small county in the United States, Singapore is the third largest port in terms of tonnage in the world (behind Rotterdam and Yokohama) and has the world's third largest oil refining capacity.

Achieving such a high ranking was not accidental. Indeed, as nearly every brochure proclaims, Singapore's potential for becoming a "great commercial emporium" was envisioned over 150 years ago by Sir Stamford Raffles. Since its founding in 1819, Singapore's shoreline has served as a focal point for commerce and industry (Figure 1). Naturally protective and strategically located, Singapore's port has undergone almost continuous modification and enlargement.

The earliest trading was centered around the mouths of the Singapore, Kallang, and Rochore Rivers all of which are located within a stretch of coast less than three km long. Trading was so good that expansion followed. New companies added their own facilities along other sections of the shoreline. Especially conducive to the expansion of this relatively remote port was the opening of the Suez Canal in 1869 and the installation of telegraph services in 1870. With these developments, Singapore strengthened its claim as the center of the region's trade.

Facilities damaged during World War II were replaced and augmented by advanced mechanical equipment, a trend that continues to the present. The Port of Singapore today, according to one of the port's brochures, handles ships from 84 countries represented by more than 150 shipping lines. No fewer than 200 ships are in the port every day and on the average one ship arrives or departs every 12 minutes.

It was inevitable that the rapid rise in the commercial importance of Singapore would be accompanied by a dramatic rise in population. With nearly 2.5 million people and an area (today) of only 618 square km, Singapore has a population density of just under 4,000 people per square km making it one of the most densely populated areas in the world. The population is mainly Chinese (77%) although Malay (15%) and Indian (6%) comprise significant minorities.

Singapore consists of one large island (92% of the area) and over 60 smaller islands and reefs most of which are little used. The urban area of Singapore is spread along the 40-km stretch of coast that makes up the south and east part of the main island.

Given such population, commercial, urban, and developmental pressures, it is not surprising that Singapore has become a leader in the art of artificially expanding its surface area. It seems that reclamation has almost become a way of life in Singapore.

- The Natural Shoreline

For a country with such a small total area, Singapore has a relatively long shoreline mainly because of its great number of small islands. Further, it is a shoreline that is continually being changed by human activities. The shorelines around no fewer than 21 (about one-third) of the smaller islands and along over two-third's of the large island have been morphologically modified.

Most of the coast of Singapore is low, although there are some cliffs that border the sea. Along the northern and western coast of the main island, cliffs and headlands are separated by mudflats, estuaries, sandy (some pocket) beaches, and mangrove swamps. The south and east coast, where present day reclamation dominates, was originally a low-gradient sandy shore. Those small islands that lie south of the main island are fringed, for the most part, by Holocene corals. Some are reefs that are continually submerged or only exposed during low water.

Protected by the Malay Peninsula on the north and by Indonesian islands on the south, most of Singapore's shoreline is only subjected to low waves. Seldom are they more than 0.6 m in height. However, a fairly high tidal range, which averages about 2.2 m during springs, presents some problems. There is a seasonal shift in the direction of the littoral drift along the southeast shoreline, the net drift is toward the west (Wong, 1973). Despite the generally low energy situation that prevails, beaches exposed to monsoon effects need more protection than others.

- Reclamation

Because of the character of the shoreline, the low-energy nature of coastal processes, and the lack of severe storms, reclamation along the coast is relatively easy. The first reclamation was begun in the 1820s along the Singapore River shortly after Raffles established his colony (Wong, In Press). From the 1820s to the 1960s reclamation was periodic and nearly always associated with expanding commercial activities. Seawalls, docks, and wharves dominated although some local private projects were undertaken.

Most of the reclamation projects of the last 20 years have been sponsored by the Jurong Town Corporation, the Housing and Development Board (HDB), and the Port of Singapore Authority (PSA). After a number of studies by local and foreign (especially Japanese) consulting firms and by the United Nations Committee for Technical Assistance, large-scale modifications of the Jurong Coast were begun (Figures 1 and 2). These modifications, which are continuing, were aimed at attracting industry as well as increasing Singapore's port facilities. The location was ideal for such development because fill material was available from nearby hills, and offshore and deep water was efficiently close to allow deep draft vessels to use developed facilities (Krausse, MS). The project has grown in scope and under present plans will not be completed until the nearly 1990s or some 30-35 years after initiation. The area shown in Figure 2, that is yet to be reclaimed, will add some six square km to Singapore's total. Many of the islands just offshore from the eastern part of the Jurong area were reclaimed (Figure 2) for use as one of Singapore's major petroleum and petrochemical centers. In the process, a number of islands have been joined reducing the total number Singapore can claim.

The islands south of Jurong are not the only islands to undergo reclamation. Many others have been modified, mostly for recreational purposes (Photos 1, 2 and 3). By 1979, some 17.14 square km had been added to 21 islands and reefs increasing their area by 86%. Island reclamation is continuing with over 5 square km being added on the southern end of Pulou Tekong, Singapore's second largest island.

The East Coast Reclamation Scheme has received much attention since first conceived over 20 years ago. In 1963, a pilot project at Bedok (Figures 3 and 4) proved successful and led to the development of a seven-phase undertaking by the HDB. The last phases (VI and VII) are now under construction (Table I and Figure 3). When completed the East Coast Reclamation project will have added over 125 square km of area to

Singapore's total. The main objective of this scheme was to provide additional land for the development of new residential areas in implementation of HDB's decentralization plan. Also some areas are being set aside for highways and recreational facilities. The sandy beach created (especially by Phase I) is over 10 km long. When phases VI and VII are completed and that area is added to the already reclaimed land from phases II, III, and V, adequate space will be available for the completion of a new city center.

During the 22 years from 1960-1982, Singapore reclaimed 36.4 square km of area and increased its total area from 581.5 square km to 617.9 square km. In 1991, when all of the planned projects are completed, another 17.6 square km will have been added. At that time, the total area of the republic will have been increased by 9.3% over its 1960 value or some 10% over what it was in 1819.

- Reclamation Technology

The technology involved in reclamation varies greatly around the world and depends on a variety of factors. It is affected by the nature of the area to be reclaimed, the size of the project, the type of material used, and the degree of protection the reclaimed area needs from the sea.

In the case of Singapore, a variety of shoreline environments have been reclaimed including mudflats, mangrove swamps, sandy shores, estuaries, and coral reefs. All provide somewhat different bases upon which the fill is to be placed and upon which any protective breakwaters will be constructed. Another problem, and one that affects greatly the cost of the project, is the source, type, and transport of the fill material. In Singapore, both offshore and inland sources have been used.

For the most part, the PSA (which has had the major responsibility for developing Singapore's offshore islands) have used dredge material in its reclamation projects. To a large extent, these materials were obtained during the maintenance of, or creation of, new navigation channels within the port for which it has responsibility.

Some of the difficulties faced by PSA in its island projects occur because of a relatively high tidal range, the shallowness of the water over the reefs being reclaimed, and the softness of the marine clays that underlie some of the coral. Because the use of split bottom barges was not feasible due to shallow water, material had to be pumped to the fill area. Tidal range presented problems especially during the construction of the embankments (bunds) around the fill area. Because armoring of the bunds is by hand, it can only be done at low tide. Lastly, the settlement of the bunds and fill, because of the low stability of the basal sediments, increases the amount of fill needed.

The techniques used in small island reclamation are well developed; those that have evolved during reclamation along the east coast are more spectacular.

Reclamation along the east coast of Singapore has been nearly continuous since the pilot project was begun in 1962. During the past two decades a number of methods, various types of equipment, and a number of sources of fill have been used. Conventional methods (steam shovels, dump trucks, and bulldozers) were used in the pilot project. However, once the major phases were begun other techniques were employed. For phases I, II, and IV, fill was obtained by a bucketwheel excavator from the hills at Bedok, transported to the shore by conveyor belt, distributed along shore by a dump conveyor, and then spread by a large spreader machine (Chen and Wei, 1979). In phases III, VI, and VII (the latter two are still under construction) fill materials were also obtained by

bucketwheel excavator (Photos 4 and 5) and transported to the shore by conveyor belt (Photo 6). However, at that point they were loaded on barges (Photo 7) and carried to the areas being reclaimed. Here they were either dumped behind previously constructed stone bunds directly into the area being filled or, after the water became too shallow for barges to operate, unloaded from the barges by large "reclaimers" (Photo 8) and conveyed to the fill area.

Reclamation in phase V (Figure 3) differed from the others in several ways. The fill was obtained by dredging sand from shoal areas in the port and transferring it by barge. During part of this operation, dredge material had to be stockpiled and transported to the fill site by floating and land pipes.

Much of the bottom along the east coast consists of fine grained sediment, therefore it was necessary to first dredge trenches where the stone bunds were to be located. These trenches were then filled with sand providing a firm base for bund construction.

Because the seaward edge of a reclaimed area becomes the new shoreline, it may need protection. Much effort (and trial and error) had been expended in Singapore on a number of coastal protection schemes. They range from doing nothing (i.e., allowing the newly reclaimed area to develop a "natural" shoreline) to the utilization of seawalls, detached breakwaters, and groins. The degree of success of these various methods has been variable.

In order to protect the reclaimed area of phases I and II, 4.5 km of seawall was constructed (Figure 4). It was placed back from the water line in the hopes that a beach would form in front. However, instead, the seawall was undermined which led to the emplacement of stone mattresses and the construction of groins both of which proved ineffective. Finally, a series of detached (offshore, headland) breakwaters was constructed (Figure 4) for the purpose of promoting beach formation between them. Two types of breakwaters--gabion and rip rap--were used. The original gabion breakwaters, which were 3.7 m high, subsided to some extent and were partially destroyed by oyster gatherers. They have subsequently been improved and repaired. Rip rap breakwaters were larger (5.2 m in height) and more durable but also more expensive. Both types have been generally effective in helping with beach formation (Wong, 1973).

- Spinoffs

Reclamation, which has increased Singapore's area by nearly 10% has been beneficial in yet other ways. It has been an effective user of dredge materials that otherwise would have been spoil, and it has led to the creation of a reservoir. Further, a number of hills have been leveled and converted into housing sites. Bedok--now called Bedok New Town--used to be a series of hills some of which were higher than the multistoried buildings that now occupy the same locations (Photo 6). Not surprisingly, there have been objections raised against this procedure. Nonetheless, such procedures have made new housing possible. In fact, HDB, which is the government organization that touches most deeply people's private lives, has created housing estates that are now used by over 70% of the population.

Some of the techniques used have advantages in addition to efficiency and cost savings. Conventional methods, e.g., the use of dump trucks, often cause high noise and pollution levels. The adaption of the conveyor belt system (one of which is 7 km long) has reduced greatly these types of pollution.

ACKNOWLEDGEMENTS

Primary arrangements for the author's visit to Singapore in 1981 were made by Dr. P. P. Wong of the National University of Singapore. Arrangements included:

- a visit to the HDB Office where a briefing on reclamation was held by Mr. Chen Seong-yean, Manager, Building and Development Division and Mr. John Wei, Principal Civil Engineer,
- a visit to the PSA Office where a tour of the harbor was arranged, and
- a field trip round the shoreline led by Dr. Wong.

Subsequent to the visit, various publications relating to reclamation in Singapore had been received from Dr. Wong. A detailed 1:50,000 scale topographical map has been prepared by the Mapping Branch, Ministry of Defense, Singapore. It depicts clearly the locations of many of the modifications that have been made along the shoreline.

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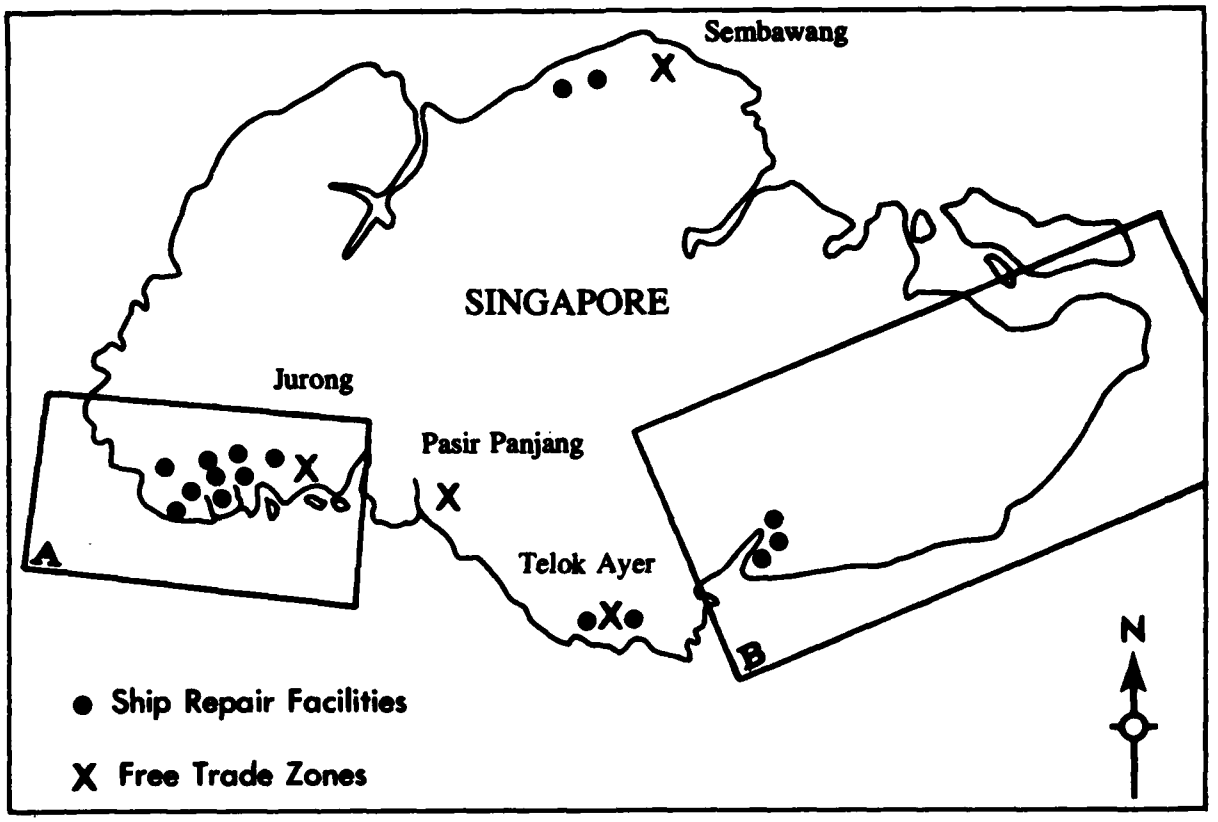

Figure 1. Map of Singapore showing the location of two of the most significant reclamation areas and of some of the major commercial locations.

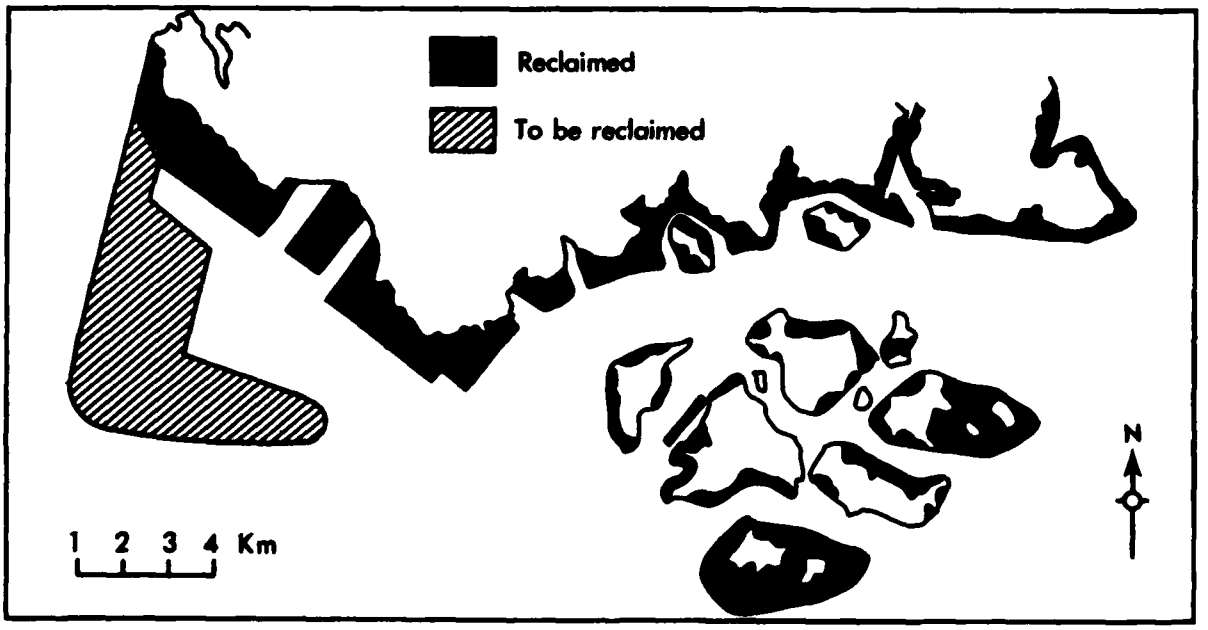

Figure 2. Map of the Jurong area (Inset A of Figure 1). [After Krausse (MS)].

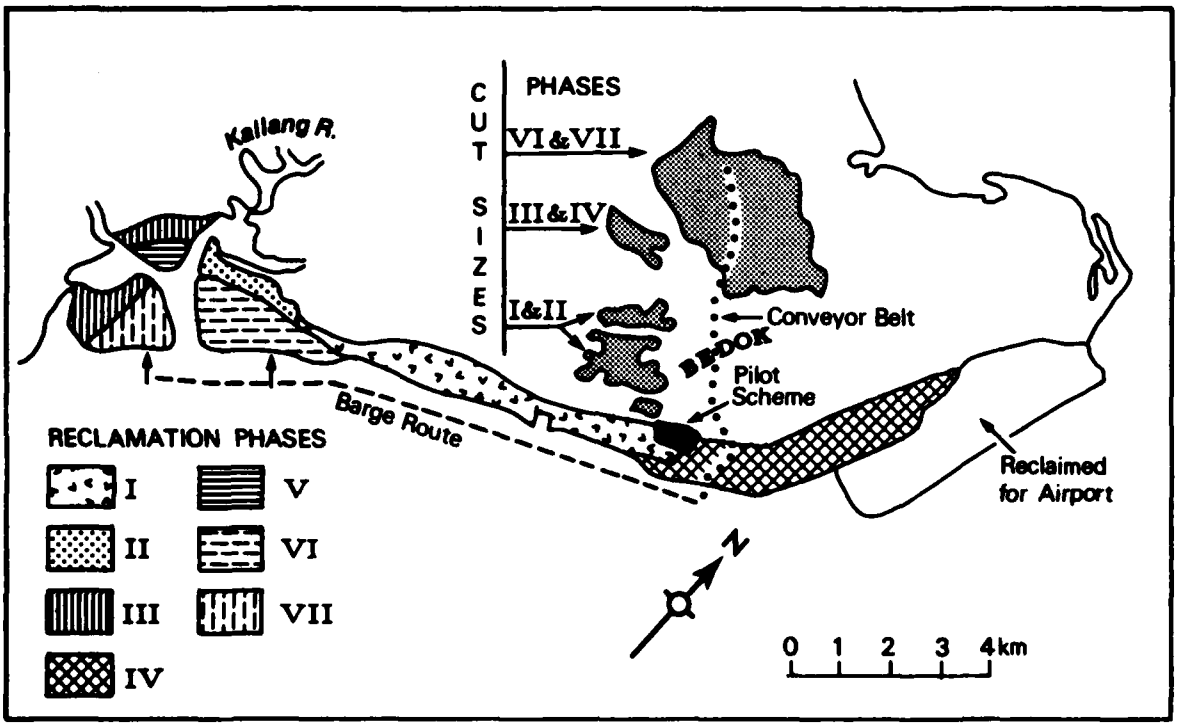

Figure 3. Map of the east coast showing the location of the seven reclamation phases (Inset B of Figure 1). Also located is the reclaimed area which serves as the site of the new (Changi) airport. (After HDB Annual Report 1979/80.)

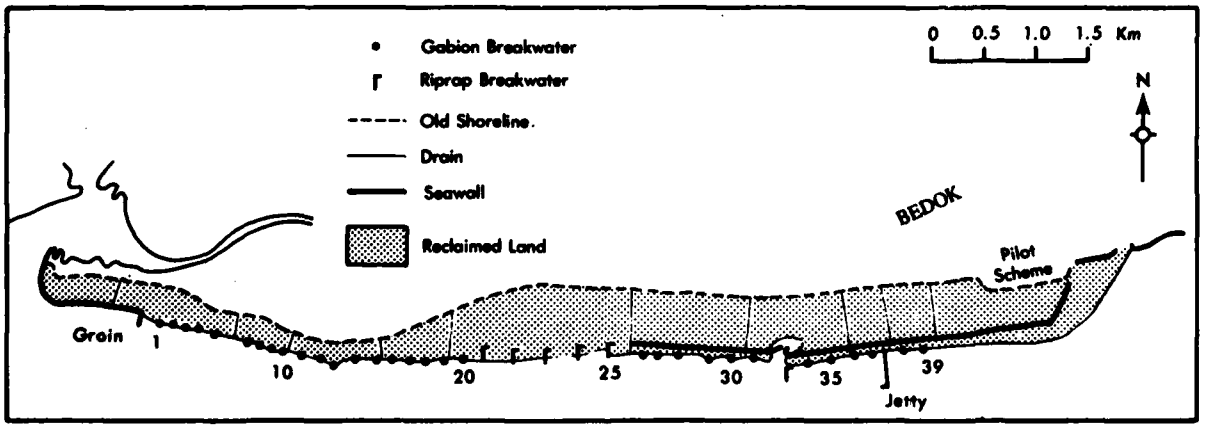

Figure 4. Detail map of Phases I and II showing the location of coastal protection structures. (After Wong, 1973.)

Photo 1. Bund on offshore island with Singapore City in background.

Photo 2. Bund on offshore island showing fill behind. Reclaimed by the PSA. It illustrates the hand placement of facing stones.

Photo 3. Offshore island with seawall which has been damaged by water pressure from beneath the wall.

Photo 4. Bucketwheel excavator and hill being removed for fill. Note size of workmen.

Photo 5. The excavating wheel of bucketwheel excavator. Photo from HDB, Singapore.

Photo 6. Conveyor belt leading from excavation site shown in Photo 4. Note new high rise residences in background.

Photo 7. Conveyor belt carrying fill materials to hopper on loading dock. Photo from HDB, Singapore.

Photo 8. Reclaimer used at end of barge haul for unloading fill material to transfer to reclaimed land.

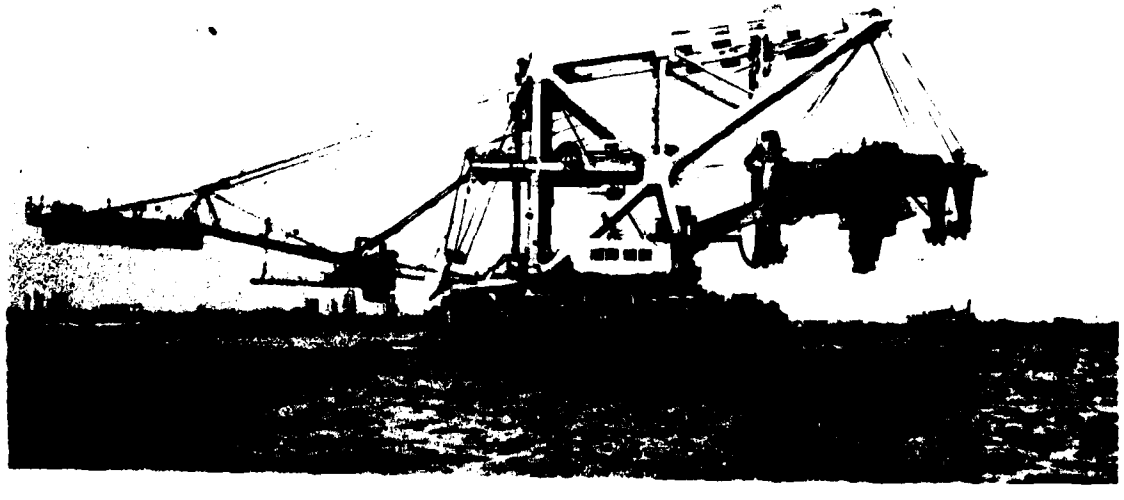

TABLE I

East Coast Reclamation Scheme*

Phase	Area Reclaimed sq km	Cost Total** S$ x 10^6	Cost per sq m S$	Period
I	4.05	45	110	1966-70
II	0.53	10	19	1970-71
III	0.67	23	34	1971-75
IV	4.86	44	9	1971-76
V	1.54	106	69	1974-77
VI	2.34	38	107	1979-85
VII	1.26			
Total	15.25	613	40	1966-85

* Adapted from Wong (In Press) and HDB Annual Report (1970-80).
** In 1983, one Singapore $ was equal to 0.48 $U.S.

PHYSICS IN MALAYSIA

Leon H. Fisher

This report is based on two trips to West Malaysia. Visits were made to four of the six universities in the country, to Tunku Abdul Rahman College and to PUSPATI, an experimental atomic reactor. The report also describes briefly a number of Malaysian and Asian professional societies and other organizations devoted to the profession of physics.

INTRODUCTION

Malaysia, a member of the British Commonwealth, is a country in Southeast Asia. It is about 80% as large as California and has a population of about thirteen million. Thirty percent of the population is urban. The population is very young; over 40% are between 15 and 29 years old.

Malaysia consists of two regions, West and East Malaysia, which are separated by 400 miles of the South China Sea. West Malaysia has 84% of the total population, but only 40% of the total land area. It is on the southern part of the Malay Peninsula; it is about 500 miles long and has a maximum width of 200 miles. West Malaysia borders on Thailand in the north and is connected by a causeway to Singapore in the south. West Malaysia contains almost all the facilities for higher education in the country. East Malaysia consists of Sarawak and Sabah, two of the 13 states of Malaysia. These two states are both in the northern part of Borneo, the third largest island in the world after Greenland and New Guinea.

Malaysia has an extremely complicated mix of racial and ethnic components in its population. The indigenous peoples consist of Malays, Dusuns, Bajaus, Muruts, Sea Dayaks (Ibans), Land Dayaks, Melanaus, and others. In addition, there are sizable percentages of the population of Chinese descent and of people with ancestral origins on the Indian subcontinent, i.e., India, Pakistan, Bangladesh, and Sri Lanka. The people from the Indian subcontinent are usually immigrants or the children of immigrants. The Chinese have been in Malaysia much longer.

The people known as Malays constitute about one-half of the population of Malaysia and control the country politically but own a disproportionately small amount of the country's resources. Malays are "bumiputras," sons of the soil, and special arrangements are made to reserve places for them in higher education, both as students and faculty.

There is a national language which is a development of the Malay language; it is known as Bahasa Malaysia (colloquially referred to as Bahasa). There is also a national religion and it is Islam; Malays are Muslims. Fifty-three percent of the population of West Malaysia is Malay, 36% is of Chinese descent and 11% is Indian, Pakistani, Bangladeshan, and Sri Lankan. The ethnic and racial composition of East Malaysia is exceptionally complicated with Malays constituting only 12% of the population. In Sarawak, the population is approximately 30% Chinese, 30% Sea Dayaks (or Ibans), 20% Malays, 10% Land Dayaks and 5% Melanaus. Sabah's population consists, among other peoples, of about 22% Chinese with a very small percentage of Malays.

Malays are predominantly rural people and constitute only 22% of the urban population of the entire country; two-thirds of the urban population is of Chinese descent and 10% consists of Indians and Pakistanis. About 85% of the population of East Malaysia is rural.

Malaysia is rich in natural resources and these have been developed to a much larger extent than those of its neighbor, Indonesia. Malaysia is the world's largest producer of rubber (it produces 42% of the world's output, but only 4% of Malaysia's output is used domestically) and tin (Malaysia produces 32% of the world's output, more than two-and-a-half times the amount of tin mined by the U.S.S.R., the second largest producer of tin in the world). Besides tin, the most important minerals are iron ore, bauxite, and petroleum. (As of now, Malaysia is a net exporter of petroleum, but this will not last more than a few more years.) It produces 49% of the world output of palm oil and 42% of the world's pepper production. Agriculture, forestry, fishing, and mining together constitute about one-third of the GNP. Twenty percent of the GNP comes from manufacturing. The main food crop is rice. Cultivation of tea and coffee are relatively new ventures and they are being pursued actively.

Among other steps taken in order to encourage foreign investment, Malaysia has established a free trade zone in Penang, near the airport, which enjoys beneficial tax and excise duty arrangements. This arrangement has brought in many American and Japanese electronic manufacturing plants as well as a few German light electrical manufacturing plants. Some of the American companies are Harris Semiconductor Malaysia, General Instrument Malaysia, Hewlett-Packard, IBM World Trade Corporation, National Semiconductor, and RCA.

MALAYSIAN UNIVERSITIES

There are six universities in Malaysia and at least five of the six are government supported. Until 1969, the University of Malaya was the only university in the country. At the present time, three of the universities are in Kuala Lumpur, the national capital, and two others are within 10 miles of Kuala Lumpur.

One of the universities can be dealt with briefly for the purposes of this report. This is the newly (1983) created Islamic University which is primarily devoted to the various fields of Islamic studies, although it will offer a complete spectrum of fields, including physics. It is at the site in Kuala Lumpur formerly occupied partly by an Islamic College and partly by the National University of Malaysia. The Islamic University is being built and financed predominantly by Moslem countries. Malaysia is paying for the operating expenses.

The remaining five universities all have physics activities. The names of these universities, both in Bahasa as well as in English, along with their acronyms and addresses follow:

- Universiti Malaya (UM)
  (University of Malaya)
  Lembah Pantai
  Kuala Lumpur

- Universiti Sains Malaysia (USM)
  (University of Science, Malaysia)
  Minden, Penang

- Universiti Teknologi Malaysia (UTM)
  (University of Technology, Malaysia)
  Jalan Gurney
  Kuala Lumpur 15-01

- Universiti Kebangsaan Malaysia (UKM)
  (National University of Malaysia)
  Bangi, Selangor

- Universiti Pertanian Malaysia (UPM)
  (University of Agriculture, Malaysia)
  Serdang, Selangor

There will probably be a seventh university which will be located in the state of Kedah, near the border of Thailand.

GENERAL COMMENTS ON HIGHER EDUCATION IN MALAYSIA

The current university enrollment in Malaysia is only about 40,000 and represents about 0.3% of the total population. (The public universities of the state of California alone enroll far more than 0.2% of the total population of the United States.) Thus higher education in Malaysia is very limited.

In 1971, the Universities and Universities Colleges Act was enacted. This act makes the Minister of Education responsible for the direction of higher education in the country and prohibits the setting up of new institutions of higher learning except under the order of the King. The act was amended in 1975 to provide for greater control over student and staff activities and for greater government control in the management of university affairs than had been the case previously.

No private schools are allowed in Malaysia except for a few, usually for foreigners. (We will be discussing one college which is half-supported by the government, the Tunku Abdul Rahman College.)

By 1982, all preuniversity schools in Malaysia had phased out English as the language of instruction. Now, all government preuniversity schools use Bahasa Malaysia as the language of instruction. Thus, all students of Chinese and Indian descent and others in Malaysian schools have to learn Bahasa Malaysia as their first language. At the time of my visits, national policy required that Bahasa Malaysia be the medium of instruction in all universities by 1983.

Officially about 55% of all university places are reserved for bumiputras. In the early years of university study there are special tutorial classes for all students who fail to achieve passing grades.

There is a large demand for undergraduate education in physics in Malaysia. Physics majors, to a large extent, end up teaching school. However, at USM, many physics majors go to work in geophysics and meteorology. There are relatively few graduate students in physics in Malaysia.

- University of Malaya [Universiti Malaya (UM)]

The University of Malaya has a somewhat complicated history which was described in this *Bulletin*, *6* (4) 36 (1981). It dates back to 1949 as an institution with the same name but has antecedents with different names dating back to 1905. UM is the largest and oldest university in Malaysia. It was established in its present form by an act of parliament in 1962. Its most immediate antecedent was called the "University of Malaya in Kuala Lumpur" and this institution was established in 1959 (there was another

branch of the University of Malaya in Singapore known as the "University of Malaya in Singapore" which subsequently developed as the present National University of Singapore).

UM has a student body of about 9000 and enrollment will be maintained at this level. Thirty percent of the students live on campus. There are ten faculties which are listed below along with the dates of establishment (given when available).

- engineering (1958)
- arts and social sciences (1959)
- science (1959)
- medicine
- education (1963)
- economics and administration (1966)
- dentistry (1972)
- law (1972)
- Syariah (Islamic law)
- Usuliddin (theology)

There is also an institution named Academi Islam established in 1981, a language center established in 1971, a computer center established in 1965, and a university hospital with 850 beds. Of special interest is the Institute for Advanced Studies which was started in 1979. It is devoted completely to graduate work and has a separate faculty. A student pursuing graduate work may work either with one of the regular faculties or within the institute. Interdisciplinary Ph.D. degrees may be pursued in the institute.

- Physics at the University of Malaya

The physics department of the University of Malaya has 20 faculty members. At the time of my visits, two were professors, six were associate professors and the rest were lecturers. At the time of my visits, Abid Hussain (Ph.D., University of Manchester) was the head of the department and had been head for about ten years. The laser laboratory, which involves eight faculty members, was established in 1978. The laser laboratory has a number of homemade ultraviolet nitrogen flow lasers operating at 3371 A°. They are superradiant devices and do not require resonant cavities. The lasers operate at pressures of about 100 Torr and are pulse driven at about 20 kV. The laser flash duration is about 20 ns. These lasers have been used to pump dye lasers.

It is hoped to carry out LIDAR (Light Detection and Ranging) pollution studies by Raman backscattering. To date, measurements have been carried out on N_2, O_2 and H_2O in normal atmospheres. Preparations were being made to study plumes. A 10 kW dye laser is not intense enough to find trace pollutants in air and the present dye lasers at UM put out about 10 kW. It takes lasers operating at 1-3 MW to detect pollutants to a few parts per million by backscatter. Backscatter is so weak that photon counting techniques are used and the detection system has been interfaced with a microcomputer and display. They will also look for scattering from particles and will try to study pollutants from car exhausts.

Homemade dye lasers (collinear and coaxial types) tuned to H_α and H_β are being used for studying transition rates in various quantum states in hydrogen plasmas. It is proposed to use this technique as a diagnostic tool in hydrogen plasmas by studying not only various lines of the Balmer series but also scattering from high quantum number atomic hydrogen states such as n=6 or n=7. In the case of the H_α line, studies are being carried out in a hydrogen plasma pinch which lasts 200 μs. The radiation is being observed at right angles to the incident laser beam.

The plasma physics activity was established in 1970 under the Colombo plan and involves five faculty members. It is headed by Associate Professor Lee Sing (Ph.D., Australian National University).

Two capacitor banks are available and both are operating. One is a homemade 60 μF 40 kV 48 kJ bank with a 2 MA short circuit current. It provides 26,000 MW in the first quarter cycle. This capacitor bank was donated by the U.K. under the Colombo plan. The bank consists of 100-0.6 μF oil-filled British BICC capacitors.

The second capacitor bank was presented by the Alexander von Humboldt Foundation and the Institute of Reactor Development and Plasma Physics of the Nuclear Research Establishment [Kernforschungsanglangen (KFA)] of Jülich, Federal Republic of Germany. It consists of a 22 μF Maxwell capacitor bank rated at 60 kV. (The Maxwell capacitors are much less bulky than the British capacitors.) It was installed in 1976 and has been operating since 1977. Actually, the facility transferred was originally a dense plasma focus machine which was converted in its last year at Jülich into a plasma vacuum spark.

Eight General Electric 7703 20 kV 100 kA mercury ignitrons are used for switching and they are operated above their rating; they are occassionally operated at 40 kV and 250 kA.

A ruby laser donated by the Alexander von Humboldt Foundation is used both as a diagnostic tool and for plasma production. It is the System 2000 designed by JK Lasers Limited, England and was purchased new. It can be operated in two modes: the multiple-transverse-mode (MTM) and the single-transverse-mode (STM). In the MTM operation, the normal power output is 60 MW (1.5 J in 25 ns) and the coherence length is a few mm. If a better spatial coherence is required (as in the case of holographic interferometry), the laser can be converted to operate in STM. In this case, the power output is reduced to 1.2 MW (30 mJ in 25 ns), but the coherence length is 1 m. While operating in a chopped mode, its pulse width can be reduced to 5 ns.

The laboratory also has several smaller capacitor banks, vacuum systems, oscilloscopes, diagnostic systems, a screened room, a transient digitizer, and an Imacon camera. The research devices include two plasma focus machines and a vacuum fusion spark.

Plasmas in the vacuum spark are produced in the following way. The capacitor bank (the German condenser bank is the one mainly used) is charged to a voltage between 20 and 35 kV and is applied to a 5 mm vacuum spark gap but the gap does not break down until a laser pulse is focused on the sharp anode. Enough of the anode is vaporized by the laser pulse to cause the condenser bank to discharge through the gap and breakdown the gap along with further vaporization of the anode. (If the applied voltage is as low as 6 kV one still gets a spark on the application of the laser pulse.) A dense spot in between the electrodes starts appearing at voltages as low as 12 kV. Most of the damage to the anode is due to the discharge and not to the laser beam. (One can use an electrode for 100 shots.) The history of the discharge is as follows. No current flows for 20 to 30 μs after the end of the laser light pulse; then the discharge current begins to flow in an oscillatory manner. The current rises at about 10^{11} A/s. Pinching occurs for currents larger than 600 kA. The electron density is measured holographically as well as by x-ray emission (x-rays are also used to determine the electron temperature) and is found to be about 10^{21}/cc. The electron temperature varies from shot to shot and lies between 2 and 10 keV. Intense bursts of x-rays occur (a few MW for 15 ns) and have energies between 4 and 10 keV. The x-rays as well as the current are quite reproducible, in contrast to the variation in measured electron temperature. (Time resolved x-ray emissions are detected

by PIN-diodes.) X-ray pinhole (800 μm) images of the vacuum spark are also made. If LiD is used in the anode, a strong burst of neutrons (10^{19} neutrons in 100 ns) is observed. (Fusion neutrons were already being produced before the German capacitor bank was installed.) Two indium foil activation detectors were used to measure the angular distribution of neutrons. Twice as many neutrons were observed in the forward as in the backward direction. The neutron energies were determined by a time of flight method and were found to have energies of 2.6 MeV in the forward direction and 2.2 MeV in the backward direction. Theoretical work is being undertaken to understand the nature of the discharge.

There are also two plasma focus machines which are operated with deuterium. Construction of a small Tokamak has more or less been completed.

- University of Science, Malaysia [Universiti Sains Malaysia (USM)]

The University of Science, Malaysia is on the southeast coast of Penang Island. Penang Island (Pulau Pinang, pulau means island) is part of the state of Penang which includes land on the mainland as well as Penang Island. Penang Island has an area of 113 square miles and is about one-third the area of Penang State. Penang Island has a population of about 350,000 and represents about one-third of the total population of Penang State. The bulk of the 350,000 residents on Penang Island is concentrated in the city of Georgetown, the capital of the state of Penang.

USM is on the outskirts of Georgetown at the site of an old British army camp. The university has a campus area of 372 acres. The university started operating in 1969 and was the second university to be established in the country. By 1980, it had an enrollment of about 4000.

The university is different from other Malaysian universities in that it is organized into schools. The schools are:

- School of Applied Sciences,
- School of Pharmaceutical Sciences,
- School of Medical Sciences,
- School of Housing, Building, and Planning,
- School of Humanities,
- School of Social Sciences,
- School of Educational Studies,
- School of Biological Sciences,
- School of Chemical Sciences,
- School of Physics,
- School of Mathematical Sciences.

I visited the university library and was impressed with the extent and nature of the collection. There is no shortage of current foreign scientific journals or of excellent modern scientific and engineering books of all kinds.

- Physics at the University of Science, Malaysia

There are 30 people on the academic staff of the School of Physics at USM and this makes it the largest physics department/school in Malaysia. There are an additional 17 faculty members, all Malay, who are out of the country getting M.Sc. degrees or Ph.D. degrees. Research is being emphasized more and more and most faculty members are involved in some kind of research. USM considers that it has one of the most active

physics department in the country. Of the 30 staff members, two are full professors, seven are associate professors, and the rest are lecturers. Everyone on the staff with the exception of a few lecturers have Ph.D. degrees. The teaching load consists of three or four lectures and two laboratories a week.

There are about 500 on campus and 100 off campus students studying physics. There are usually somewhere between 20 and 50 single subject physics majors. There are also a number of "double" subject majors involving physics, i.e., physics/mathematics, education/physics and physics/biology. Students with bachelor's degrees are in demand as schoolteachers, in hospitals, in geophysics, and in meteorology.

All the research activity is carried out in groups. Each group consists of a number of faculty members, one of them being designated as the group leader.

The principal research areas along with the number of faculty members (in parentheses) and the subareas of interest within each area are:

. Biophysics (7)

trace element analysis,
environmental radioactivity measurements,
interaction of radiation with matter, instrumentation,
physical properties of biological tissues,
hemodynamics,
neutron activation analysis in molecular biophysics,
membrane biophysics.

Equipment includes a neutron generating facility manufactured in France which is about four years old. It produces 14 MeV neutrons from a DT reaction on a tritium target yielding a continuous neutron flux of 10^{10}/s. Other equipment includes two gamma ray spectrometers utilizing Ge-Li drifted detectors, one NaI spectrometer, one high purity Ge detector, scintillation counters and optical spectrometry capabilities.

. Geophysics (5)

USM has the only physics department in Malaysia involved in geophysics.

geophysical exploration,

oceanographic physics,

regional surveys in Malaysia of gravitational, magnetic, and electromagnetic fields,

development of seismic shallow reflection procedures,

earthquake assessment studies,

computer modelling of geophysical data,

measurement of atmospheric and surface level ozone and other meterological parameters.

Facilities include a marine recording magnetometer.

. Energy Studies (3)

solar radiation transfer studies,

humidity control for energy conservation in tropical air conditioning,

monitoring of solar radiation,

materials studies,

evaluation of biomass as an energy source,

direct conversion of solar energy into electricity for domestic lighting in remote areas.

Facilities include a solar cell unit, evaporation unit, diffusion and oxidation facilities, etc.

. Solid State Physics

measurement of thermal, electric, and dielectric properties of semiconducting and amorphous materials,

thin films,

photovoltaic materials.

. Crystallography (4)

identification of materials and nondestructive testing using x-ray diffraction and x-ray fluoresence techniques,

crystallographic computing.

Facilities include a four circle automatic single crystal diffractometer, x-ray powder diffractometer, x-ray fluoresence spectrometer and a variety of powder and single crystal cameras.

. Theoretical Physics (4)

atomic and nuclear physics: electron-atom scattering, nuclear sum rules,

condensed matter physics: modulated structures in solids, light scattering from materials containing Cr_2O_3,

high energy physics: classical gauge-field theory and quantur chromodynamics.

- University of Technology, Malaysia [Universiti Teknologi Malaysia (UTM)]

The University of Technology, Malaysia was founded in 1972 and is located in Kuala Lumpur. The origins of the university go back to a British technical school started in 1925 for the public works department. In 1930, it became the center for training

technical assistants for various government departments. After the second world war, the school became the "Technical College." In 1960, university-level courses leading to professional examinations of U.K. institutions of civil, electrical, and mechanical engineers were started.

The university continues to offer diploma courses as well as offering courses leading to undergraduate degrees. Except for mechanical engineering, no higher degrees are offered. Eventually, it is expected that there will be programs for the M.Sc. and Ph.D degree like there are at USM and UM, but this is probably some years off.

At the present time, the enrollment is about 4000 and it is increasing by 10% annually. Eventually, by 1987-1989, it is expected that the enrollment will reach 8000.

The university has departments of architecture, chemistry, computer science, civil engineering, electrical engineering, mechanical engineering, mathematics, physics, and surveying as well as a department of town and country planning. A program for applied science is being proposed.

- Physics at the University of Technology Malaysia

There are 37 members on the physics faculty. Three of them are associate professors and the rest are lecturers, including tutors and demonstrators. Some of the members are continuing with graduate studies. The faculty is mostly Malay although there are some faculty members on a contract basis from Bangladesh, Turkey, and Japan.

The principal activity of the department is the training of students to be science teachers or to become government officials with activities involving science. The teaching load is very heavy, 14 to 16 hours a week, and there is little research activity.

The physics department has one of the best equipped laboratories in Asia for undergraduate training in nuclear particle detection. It has 20 ORTEC detection systems. It also has a large number of photon counting systems as well as alpha, beta, and gamma ray computer controlled spectrometers as well as x-ray crystallographic equipment. This equipment represents an expenditure of around U.S. $2.0 million dollars. The funds came from Arab countries. The department is looking for outside people to guide the department technically in the use of this equipment as the present staff has no such expertise. The International Atomic Energy Agency (IAEA) has been asked to send someone for this purpose.

- National University of Malaysia [Universiti Kebangsaan Malaysia (UKM)]

The National University of Malaysia opened in 1970. The main campus of the university is at Bangi, Selangor, 20 miles south of Kuala Lumpur. (The university has a branch campus in the city of Kota Kinabalu, the state capital of Sabah, on the northern coast of Borneo.) The campus is seven years old but most of the buildings were constructed recently; the former campus was near the University of Malaya. The enrollment is about 6000, but it is planned to have 10,000 students by 1985. Ninety-five percent of the students live on campus. At the time of my visit there was no engineering faculty, but plans were being made to start recruiting such a faculty. UKM offers both undergraduate and graduate training (M.S. and Ph.D. degrees are available) but there is very little graduate work carried out in the sciences. It takes four years to obtain an undergraduate degree. The university, at the present time, grants about one Ph.D. degree annually.

The faculty is predominantly Malay. The university receives more development funds than does any other university.

The university has departments of:

- accounting,
- anthropology and sociology,
- Arabic studies and Islamic civilization,
- biochemistry,
- botany,
- chemistry,
- communication,
- economics,
- education,
- electronics,
- food science,
- genetics,
- geography,
- Islamic law,
- languages,
- Malay language and letters,
- management,
- mathematics,
- medicine,
- microbiology,
- nuclear science,
- physics,
- political science,
- Koranic studies,
- statistics and computer science, and
- theology and philosophy.

The physics department, which recently moved to the campus at Bangi, was split up into three departments: physics, nuclear science, and electronics with 16, 8, and 9 faculty members respectively. The chairman of the physics department is Muhamad Yahaya, Associate Professor, who received his Ph.D. from Monash University. The department is very well equipped and has a good deal of modern equipment, although no substantial research is as yet underway. They have a Philips DT neutron generator and a Californium source donated by IAEA. There are plans to undertake research in solar energy.

- University of Agriculture, Malaysia [Universiti Pertanian Malaysia (UPM)]

The University of Agriculture, Malaysia was established as a university in 1971 and is located at Serdang, about 14 miles south of Kuala Lumpur. It occupies the site of the former College of Agriculture and has also taken over the diploma program that was offered by that college. The university has eight faculties:

- agriculture,
- forestry,
- science and environmental studies,
- veterinary medicine and animal science,
- agricultural engineering,
- resource economics and agribusiness,

- education,
- fisheries, and
- continuing education.

There are about 3500 students enrolled. The enrollment will be allowed to expand to 9000. The university has a branch campus on the island of Borneo in Semengok in the state of Sarawak. At present the Semengok campus conducts one year prediploma courses and diploma courses in agriculture and forestry. The main campus offers both undergraduate and graduate degrees including the Ph.D. in all faculties.

- Physics at the University of Agriculture, Malaysia

The department of physics was formed in 1974 and currently has 19 faculty members. One is an associate professor and the others are lecturers.

Research interests of the department are in material sciences and solid state physics, biophysics, and radiation biology, and applied and instrumentation physics. Specific research topics contemplated or in progress are now listed:

dielectric and electronic properties of Hevea latex,

portable microwave device for measurements of dry rubber content of fresh Hevea latex,

application of microwave heating to the extraction of rubber from fresh Hevea latex,

compositional and temperature dependence of tensile strength of vulcanized rubber,

microstructure and microhardness of tin, alloys of tin and cast iron,

optical properties and electrical conductivity of thin films of organic materials and of composites,

sputtering of thin film semiconductors,

measurement of traffic and motor vehicle noise,

use of electrical resistivity and refraction seismological techniques to locate ground water,

use of positron annihilation to study defects in metals.

- Tunku Abdul Rahman College (Kolej Tunku Abdul Rahman)

Tunku Abdul Rahman College has already been mentioned. It is a very unusual and interesting academic institution. Abdul Rahman was the first prime minister of independent Malaya (1957) and continued on in that post on the formation of the Federation of Malaysia in 1963. (Tunku is the Malay word for prince.)

The college was founded in 1969. It is in Kuala Lumpur and 90% of the student body is Chinese. It is half-supported by government funds; the other half comes from private sources. The college is not allowed to grant Malaysian degrees but the degrees which are granted are "recognized" by the Malaysian government. These degrees are designated as

external B.Sc.s and are granted by Campbell University, which is in Buies Creek, North Carolina, in conjunction with Ulster Polytechnic, Belfast, United Kingdom. This three year external B.Sc. program started in 1978.

The college has an enrollment of 7000 and has no quota. The purpose of the college is to provide higher education for those not able to get into Malaysian universities because of enrollment limitations of one kind or another and who either do not choose to study abroad or for whom overseas education is too expensive. Instruction is in English and tuition is charged.

The college has four schools:

- School of Arts and Sciences,
- School of Business Studies,
- School of Technology, and
- School of Preuniversity Studies.

Most students are in the School of Business Studies.

The School of Arts and Science is the only school that offers a degree. The school also offers courses leading to a diploma. There are about 300 majors in the four sciences offered in the school: biology, chemistry, physics, and mathematics.

- Physics at Tunku Abdul Rahman College

Students wishing to study physics must pass the STP/HSC (Sijil Tinggi Persekolahan/Higher School Certificate) examination. A three-year program leads to a diploma or a degree. The courses followed for the diploma and degree are identical. The college provides very good instruction in physics and has very well equipped laboratories. Examination questions must be sent to Campbell University for approval.

- Mara Institute of Technology [Institut Teknologi Mara (ITM)]

Perhaps it is worthwhile to mention the existence of a rather large technological institute, the Mara Institute of Technology [Institute Teknologi Malaysia (ITM)]. The institute has an enrollment of over 9000 and a faculty of about 750. Its main campus is in Shah Alam, a city near Kuala Lumpur. ITM has four other operating campuses: one in Sabah (enrollment about 400), one in Sarawak (enrollment about 400), one in Terengganu, a state in northeastern West Malaysia, (enrollment about 400) and one in Perlis, a state in northwestern West Malaysia, (enrollment about 600).

Subprofessional, professional, and some degree-level courses are offered. Most of the programs last three years and lead to diplomas. There are no bachelor degrees given in science, but bachelor degrees are given in journalism and business administration.

Plans are being made for the enrollment at Shah Alam to reach 10,000 and for the other campuses to reach enrollments of 2000 each. Construction has started on a sixth campus in Johor. Two other campuses have been approved, one in Pahang state and the other in the Kelantan state, but construction of these campuses had not yet started at the time of my visits.

- Ungku Omar Polytechnic

Ungku Omar Polytechnic is in the city of Ipoh in the state of Perak. It was founded in 1969 with UNESCO aid. It has about 2000 students.

- PUSPATI (Research Reactor)

PUSPATI is an organization set up in 1972 and consists primarily of a research reactor. PUSPATI is the acronym for Pusat (Center) Penyelidikan (Research) Atom Tun (a Malaysian title) Ismail (the name of a former Malaysian deputy prime minister). PUSPATI is located in Bangi, Selangor, close to both the National University of Malaysia and to the University of Agriculture, Malaysia as well as to the Malaysian Agricultural Research and Development Institute (MARDI) (Institute Penyelikan dan Kemajuna) which is in Serdang, Selangor. The director of PUSPATI is Dr. Abdul Rahman Ghazali who was most recently deputy vice chancellor of UKM. Ahmad Tajuddin (Ph.D., University of London) is the deputy director.

Although PUSPATI was set up in 1972 and was designated as a National Research Center in 1973, it remained a paper organization until recently. PUSPATI is being operated under a Regional Cooperation Agreement (RCA) under the auspices of the International Atomic Energy Agency (IAEA). Other Asian countries including Japan (and Australia) are participating.

The reactor is a General Atomics Triga Mk II reactor. This is a thermal research "swimming" pool reactor. It has a 1 MW rating for steady state operation and 1200 MW for pulsed operation. The neutron flux at full power would be $3 \times 10^{13}/cm^2$ at the core center. The coolant is demineralized pure water and the fuel is U^{235} mixed with ZrH. The maximum fuel temperature is 500°C. The first critical state was obtained on 28 June 1982. Public services to universities and to the private sector such as irradiation and production of radioisotopes, etc., are not yet available. The broad objectives of PUSPATI are the training of people for nuclear work and to carry out research and development work in nuclear science and technology. It is hoped that some short-lived isotopes will have been produced by the end of 1983. PUSPATI will produce short- and medium-lived radioisotopes for application in medicine, agriculture, and industry.

The long term programs of PUSPATI include:

- Reactor systems and energy studies.

  Assessment of various power reactor systems available; analysis of the country's energy options.

- Uranium and thorium studies.

  Assessment of potential uranium and thorium resources in the country; monitoring of international supply and demand of these materials.

- Siting and safety studies.

  Includes radioactive waste treatment and disposal.

- Nuclear instrumentation and semiconductor technology

- Radiation chemistry and biology

PUSPATI will supply the following services:

- Radioisotopes and radiopharmaceuticals.
- Personnel monitoring.

  PUSPATI is a provisional member of the WHO/IAEA network of Secondary Standard and Dosimetry Laboratories (SSDL) and an entire building block has been set aside for this purpose; calibration of therapy and protection dosimeters will be carried out.

- Advisory services on maintenance and repair of nuclear instrumentation.
- Irradiation service.
- Nuclear analysis for applications to mineralogy, medicine, and the environment.
- Advisory services for safety procedures relating to the use of radioisotopes and provision of advisory services on the uses of radioisotopes.
- Nuclear science and technology information service.

  PUSPATI is a member of the International Nuclear Information Service (INIS) and will provide information to local scientists.

- Training.

  PUSPATI will be conducting training courses to develop manpower trained in nuclear techniques.

- Malaysian Institute of Physics (Institut of Fizik Malaysia) and the *Buletin Fizik*

The Insitut of Fizik Malaysia was inaugurated in 1973 and Professor B. C. Tan is president. The institute has organized a number of national and regional meetings. The institute held an international conference on "Physics and Technology in the Eighties" in 1980 in Kuala Lumpur. Two hundred people from Malaysia attended along with 30 people from abroad. The institute has 350 members and meetings are held at least once a month.

The institute has been publishing a quarterly journal, the *Buletin Fizik*. This journal accepts contributions either in English or in Bahasa Malaysia. If the contribution is in Bahasa Malaysia there is a short abstract in English. The *Buletin* has been serving the needs of physicists in Malaysia and their regional neighbors on matters involving research, educational activities, and curriculum design. The format is flexible and may contain not only full length papers but may also include status reports on research, extended summaries, proceedings of international meetings held in Malaysia, and news items of meetings. A very interesting and attractive issue was the 236-page December 1980 one containing the papers presented at the "International Conference on Physics and Technology in the Eighties" mentioned above. The *Buletin Fizik* ceased to exist on 30 December 1983 and the *Jernel Fizik Malaysia (Malaysian Journal of Physics)* was inaugurated on 1 January 1984. Articles submitted to the *Journal* will be stringently refereed and an international advisory board is being appointed.

The Malaysian Institute of Physics will begin publication of a magazine (name yet to be decided) which will be less academic and more popular than either *Buletin Fizik* or the new *Journal*.

The institute also publishes *Physics News (Berita Fizik)* bimonthly for circulation among its members only.

- ASEAN Institute of Physics (ASEANIP)

Indonesia, the Philippines, Thailand, Singapore, and Malaysia all have institutes of physics. A meeting of all of these institutes was held in Kuala Lumpur in 1980 and a new organization was formed, the ASEAN Institute of Physics. B. C. Tan of UM is chairman pro tem. Probably meetings will be held biannually. A regional journal will be published. UNESCO supplied $3,000 for 1982 and $5,000 for 1983. Only institutional membership is possible; one cannot join directly.

- Asian Physical Society (APSO)

The Asian Physical Society (APSO) was formed in 1977. Funding for APSO comes from UNESCO and COSTED (Committee on Science and Technology in Developing Countries). APSO has sponsored a number of meetings in various countries. Among other projects, APSO has plans for the following activities:

- organization of symposia, workshops, conferences, short-term courses, etc.,
- publishing a *Newsletter* and an *Asian Journal of Physics*,
- getting international organizations to hold more conferences in Asia,
- acquiring a research vessel for research in oceanography, meteorology, and off-shore exploration to be used by Asian scientists,
- developing an instrumentation center for the training of manpower to provide repair, servicing, and maintenance and to carry out R and D instrumentation and scientific equipment,

Further information may be obtained from:

Professor S. Radhakrishina
Executive Secretary, APSO
Physics Department
Indian Institute of Technology
Madras 600 036
India

- Asian Physics Education Network (ASPEN)

The Asian Physics Education Network is a body that was established in 1981. Its headquarters are in Kuala Lumpur. It serves the interests of high schools and universities of such countries as South Korea, People's Republic of China, Afganistan, Indonesia, Malaysia, Australia, India, Papua New Guinea, and Thailand. Representatives from all of the above countries attended the inaugural meeting. The first conference sponsored by ASPEN was held in Kuala Lumpur in August 1982 on the campus of UKM. The title of the

conference was "Teaching Aids in Physics Education (TAPE)." Two hundred Malaysians and 50 foreigners attended. ASPEN is supported by UNESCO. TAPE was sponsored by UNESCO, COSTED, the Institute of Physics Malaysia and PETRONAS, the National Oil and Petroleum Agency.

- Malaysian Association for the History and Philosophy of Science (MAHAPS)

The Malaysian Association for the History and Philosophy of Science was formed about a year ago. There is a growing awareness in Malaysian universities of the importance of providing students with some feeling for the history of thought. At UM for example, the history and philosophy of science is a compulsory subject for all science students. MAHAPS is a natural extension of this movement.

- Asian Regional Conference of University Physics Education

The Asian Regional Conference on University Physics Education was organized by Professor Chatar Singh and USM and was held in May 1977 at USM. There were 98 participants from 11 countries including Australia, Bangladesh, Hong Kong, India, Indonesia, Malaysia, the Philippines, Singapore, Sri Lanka, and Thailand. The conference proceedings describe physics education in the various countries represented and makes very interesting reading for anyone interested in physics education in this part of the world. A copy can be obtained from Professor Chatar Singh.

- First Tropical College for Applied Physics: Plasma and Laser Technology

As of the time this report was being prepared, the First Tropical College for Applied Physics: Plasma and Laser Technology was scheduled to be held at the University of Malaya from 26 December 1983 to 14 January 1984. The location at the University of Malaya is a very appropriate one as the University of Malaya has the strongest research activity in plasma physics and lasers in the country.

The purpose is to bring together people from third world countries such as India, Africa, the Philippines, and other countries from Southeast Asia for hands on training in plasmas and lasers. The participants will mainly come from ASEAN countries.

The college is being sponsored by the University of Malaya, UNESCO, ICTP, APSO and the Lee Foundation. The college is a joint effort of the Malaysian and the ASEAN Institutes of Physics.

ACKNOWLEGEMENTS

I am indebted to David Bradley of USM and Ng Kwan of Tunku Abdul Rahman College for assistance in collecting data for this report and for their kind hospitality.

FIBER OPTICS IN JAPAN

Ching-ten Chang, Steven J. Cowen, Michael E. Kono and Howard E. Rast

INTRODUCTION

During the period June through early July 1983, four scientists and engineers from the Naval Ocean Systems Center (NOSC), San Diego, California, traveled to Japan for the purpose of visiting Japanese industry and conducting technical discussions in the area of fiber optics. They additionally participated in the Fourth International Conference on Integrated Optics and Optical Fiber Communication (IOOC '83) held in Tokyo on 27-30 June 1983. This article summarizes some of our impressions and discussions resulting from laboratory visits. The IOOC '83 conference is not discussed in this article.

All of the laboratories we visited were within the Tokyo area. Although there is excellent research conducted in laboratories outside the Tokyo area, the limited time available precluded visits to those facilities. We found that one visit per day was the optimum arrangement to provide adequate time for laboratory tours and in-depth technical discussions. Needless to say, fiber optics is now a large and active technical specialty whose rapid growth requires the services of many disciplines, including electronics, semiconductor physics, engineering, optics, chemistry, ceramics, and communications. Because of the breadth of current work in fiber optics, however, this article tends to emphasize our own primary interests and should not be construed as an exhaustive survey of Japanese efforts in this field.

The NOSC team visited three laboratories of the Nippon Telegraph and Telephone Public Corporation (NTT) at Atsugi, Ibaraki, and Musashino. Further, we visited Fujikura Electric Company; Fujitsu, Ltd.; Furukawa Electric Company, Ltd.; Hitachi Central Research Laboratory; Kokusai Denshin Denwa, Ltd. (KDD); Nippon Sheet Glass Company, and Sumitomo Electric Industries, Ltd. Finally, we visited and participated in discussions at the Tokyo headquarters of the Optoelectronic Industry and Technology Development Association.

In general, we were quite favorably impressed not only by the customary Japanese cordiality and hospitality, but more importantly, by the Japanese commitment to and activity in fiber optics research, development, and applications. The following sections summarize these impressions.

NIPPON TELEGRAPH AND TELEPHONE PUBLIC CORPORATION

- Atsugi Electrical Communications Laboratory (ECL)

The Atsugi Electrical Communication Laboratory (ECL) of Nippon Telegraph and Telephone Public Corporation (NTT) is a recent addition (less than one year old) to the NTT laboratory complex, bringing the total number of NTT research and development facilities to four. The Atsugi ECL is chartered to originate far-reaching concepts and technology which can be transfered to the remaining NTT laboratories for ultimate development. The staff is composed of a small number of highly-regarded technical personnel from the other NTT laboratories. Support in the form of quality personnel, equipment, computers, and physical plant appeared overwhelming in view of the fact that this is intended to be only a small laboratory manned by perhaps 100 persons. The commitment to research and development by NTT, demonstrated by the magnitude of such

an investment as Atsugi ECL, was frankly somewhat staggering to us even in view of the other excellent facilities which we had seen in Japan (and in the United States for that matter).

We were accompanied on our visit by members of the Office of Naval Research, Far East office to meet with Dr. Makoto Watanabe, technical director of the Atsugi Electrical Communication Laboratory and deputy director general of the Research and Development Bureau for the Japanese government. Attending the meeting also were Dr. Ikegami, director, functional device division, Dr. Nakashima, senior staff, integrated circuit applications, and Mr. Nanishi, NTT planning and coordination office. A discussion of the ECL and a tour of the laboratory followed. We were shown the CAD/CAM facility which will be employed to design next generation VLSI devices. CAD/CAM is presently fabricated around an IBM 370 computer, and is being employed primarily to design a supercomputer employing parallel array processor architecture which will replace the existing IBM machine and have perhaps 1000 times greater capability in the role of a CAD/CAM processor. Because of prior Japanese deficiencies in CAD/CAM technology, semiconductor technology has focused upon LSI devices such as high density semiconductor memory whose step-and-repeat nature does not strictly require CAD/CAM for design and layout. It is apparent that the situation will be changing in the not so distant future. We were shown large clean room facilities (containing ultraclean modules within them) for ongoing development of ultradense VLSI. Additionally, our visit included a tour of the crystal fabrication facility, in which ultrahigh quality semiconductor boules are grown and fabricated into wafers. We were shown low defect indium phosphide and gallium arsenide boules and wafers which are required by the fiber optics industry for fabricating injection lasers and long wavelength photodetectors. We were also shown 10 cm diameter silicon wafers which will eventually be required by the semiconductor industry for economical fabrication of VLSI.

Atsugi ECL symbolized to us the nature of the role of research and development to Japanese industry--long-term payoffs are gained only through long-term investments in capital, manpower, and career commitments. Industry and government are willing to invest in a nearly unlimited scope of research and development as the key to future success in the world markets. The research and development communities in turn appear to be responsible for setting realistic long-term goals, considering not just science and technology, but also economics and marketing. Performance and growth of the Japanese industrial complex in the last twenty years or so is a clear testimony that the system works well.

- Ibaraki Electrical Communication Laboratory

The Nippon Telegraph and Telephone Public Corporation (NTT) (mentioned above) has four major communication laboratories within its research and development bureau. They are located at Atsugi, Ibaraki, Musashino, and Yokosuka. The Ibaraki Electrical Communication Laboratory is located in Tokai, Ibaraki Prefecture. This laboratory is roughly analogous in philosophy and mission to the Bell Telephone Laboratories. The Ibaraki facility, however, is small by comparison with a staff of about 300. The laboratory is active in a number of areas of optical transmission technology including research on fiber fabrication by vapor axial deposition (VAD), waveguide switch development, fiber fusion splicing technology, Josephson junctions, coherent optical transmission, polarization maintaining fibers, and materials for fiber transmission in the wavelength region beyond 2.0 μm.

The NOSC team was hosted by Mr. Norio Takato, assistant chief of the optoelectronic department who has been active in research on plastic waveguides. After the customary briefing on the laboratory, we were led on a facility tour. Due to the limited time available, only a few technology areas could be seen. These included VAD preform preparation, high fluorine glass and chalcogenide glass research for mid-IR fiber transmission, polarization maintaining fibers, and optical switch development.

NTT Ibaraki is noted for its significant contributions to the attainment of ultralow loss silica fibers, achieving losses of 0.2 dB/km at 1.55 μm in 1979. They have also been noted for their work on preparing single mode fibers by the VAD process. Until recently, most single mode fiber fabrication has been done by the modified chemical vapor deposition (MCVD) process. In fact, one of the major differences between U.S. and Japanese practices in fiber manufacture is the Japanese specialization in the VAD technique. The VAD process is the nearest thing to a quasi continuous process, which is preferable to batch-type processing such as MCVD or OVPO (outside vapor phase oxidation). Only MCVD or OVD fibers are commercially available from U.S. vendors. The NTT work on VAD has been emulated by the major Japanese fiber suppliers such as Sumitomo, Furukawa, and Fujikura. Essentially, the VAD process involves the deposition of silica soot on the substrate by multiple flames to achieve a graded or step-index profile. The preform is subsequently sintered, collapsed, and elongated in separate steps before furnace drawing. The principal advantage over MCVD is the capability of producing very large preforms of high quality from which multikilometer lengths of fiber may be pulled. NTT has a small group devoted to the improvement of this process.

We next were shown the laboratory where research activity is very intense in mid-infrared fiber technology. Research in mid-infrared fiber technology is brisk in Japan, and, in particular, at NTT. The group at NTT Ibaraki has heavily contributed to advances in the area. Although infrared fibers have been around for some time in the form of bundles for short distance imaging, the prospects for applying them to telecommunications is of recent realization since the discovery of glass forming heavy metal fluorides by Professor J. Lucas and his associates at the University of Rennes. The interesting feature of these materials is that theoretical loss spectra indicate extremely low transmission and scattering losses in the 2-6 μm range. Estimates are that losses of the order of 10^{-3} dB/km are attainable. If this goal is realized, the implications for long distance, unrepeatered data transmission are enormous. Other applications include new and innovative sensors, high power optical transmission, and wideband color multiplexing.

The NTT group is concentrating on the so-called halide glasses (BeF_2, ZrF_4, HfF_4, AlF_3/BaF_2, etc.) and chalcogenide glasses (As_2S_3, As_2Se_3, GeS_3, etc.). This group recently reported losses as low as 10 dB/km in the halide glasses at 2.5 μm. The major contributors have been Drs. Tadashi Miyashita, Toyotaka Manabe, and S. Mitachi along with their associates, T. Kanamori, K. Jinguji, Y. Ohishi and M. Horiguchi. The preparation of halide fibers is done by two methods: in one technique, a core is cast in a mold and the cladding is poured around the core to make preforms. In the other method, the cladding glass is poured into a mold, the outer surface is allowed to cool below the glass transition temperature and the center part is poured out while still fluid. Subsequently, the central region is filled with core glass and the system is annealed to form the preform. Fibers are subsequently drawn in an electrical furnace. The Naval Research Laboratory uses a variation of this process, called the rotating casting technique, in which the cladding glass is spun in a cylindrical mold while cooling; then the central region is filled with core glass. There is a multitude of glass forming halides which can be used. The compositions may be binary, ternary, or quaternary or even simple fluorides of the zirconate family (ZrF_4, BaF_2, GdF_3, AlF_3). Although fibers

have been successfully drawn and the NTT group can achieve losses as low as 10 dB/km at 2.5 μm, further progress has been plagued by scattering and impurity absorption from metal ions such as Fe^{3+}, etc. These ions are very difficult to remove by standard purification methods such as sublimation. The NTT group is attempting to remove these impurities while also reducing core-cladding interface scattering losses. Their progress is remarkable and there is sufficient optimism to hope that losses will be less than 1 dB/km sometime in 1984.

The NTT laboratory is also involved with research on polarization preserving fibers and applications. The Japanese call these "Single Polarization Single Mode Fibers." Essentially, these are fibers which have a high degree of modal birefringence so that linear polarized light can be transmitted over long distances. Such fibers are useful in applications where random, circular, or elliptical polarization would cause problems; for example, in coherent transmission, interferometry, optical gyroscopy, and fiber sensors. There have been two approaches to fabrication of these fibers. In one method, a highly elliptical core is used. The other approach is to induce birefringence by stress while maintaining a circular cross section core region. The NTT group fabricates stress birefringent fibers. They prefer this method because it is possible to reduce polarization mode dispersion, which can be as large as 200 ps/km in elliptical core fibers. In the manufacture of the stress birefringent fibers, two circular regions of borosilicate glass are positioned within the cladding region of the preform in a bilaterally symmetric configuration on an axis which bisects the core region. The borosilicate dopant region is separated from the core region by more than five times the core diameter. Because of the differences in thermal expansion of the dopant and cladding, a residual stress is induced when the fiber is drawn and which results in the observed birefringence. NTT selects waveguide parameters such that stress differences occur in the core, and conditions these parameters so that the polarization mode dispersion is zero. From these design conditions, one may obtain fibers with modal birefringence of 5×10^{-5} or better. The beat lengths of these fibers vary from 2-25 mm.

In addition to the foregoing work, NTT is active in optical switch development. The work shown to us was based on the optical and dielectric anisotropies of nematic liquid crystals. These are essentially sandwiched layers of liquid crystal on a thin film waveguide structure. By applying an electric field, the molecules of the liquid crystal align with the field direction and change the angle of light propagation. To reduce optical losses, the liquid crystal is employed as a cladding layer rather than the waveguide itself. The switching angle is a maximum with a value of twice the critical angle of total reflection. The device is designed so that only half of the upper electrode is deposited, creating two zones in the liquid crystal cladding layer. Thus, when the field is applied, only the molecules within the electrode region are aligned. Therefore, the critical angle of total reflection is given by $N_2 = N_1 \cos\theta_C$, where N_2 and N_1 are the refractive indices of the two regions. The group has successfully fabricated 2x2 matrix switches and is working on more elaborate devices. The insertion losses are rather high (>5 dB) with propagation losses on the order of 2 dB, but this is an order of magnitude improvement over previously reported liquid crystal switches. The NTT devices will operate at 1.3 μm, but their switching times are rather slow (>1 ms).

In summary, the Ibaraki ECL visit was extremely interesting and informative. The high quality of personnel and ongoing research is impressive. The NOSC team regrets that more time was not available to see all of the relevant research in the guided wave area.

- Musashino Electrical Communication Laboratory

As noted above, there are four NTT ECL laboratories which are located at Musashino, Ibaraki, Yokosuka, and Atsugi. There are 1500 employees at Musashino ECL, which is the largest among the four NTT laboratories. Musashino ECL is the principal laboratory responsible for research and development of electronic switching systems, memory equipment, integrated circuits, and semiconductor components. Fundamental research is also conducted on future communication systems, future information processing systems, new components, and new materials.

Our host was Dr. S. Shimada, deputy director of the research division of NTT Musashino. There are 200 people in Dr. Shimada's research division. Research performed in this division includes fifth generation computers, fiber optic communication, VLSI, character and speech recognition, and material science. Due to the limited time available, we were briefed only on various activities related to optical fiber communications and then were led on a laboratory tour of the molecular beam epitaxy facility.

The research on "Coherent Optical Fiber Transmission Systems" was presented to us by Dr. S. Saito, who later gave a similar topic as an invited paper at the Fourth International Conference on Integrated Optics and Optical Fiber Communication (IOOC '83). It is interesting that coherent free-space optical communication has been studied extensively in universities, but relatively little attention has been paid to coherent fiber optic communications in the U.S. Coherent optical fiber transmission systems that use optical amplitude, frequency, and phase information are expected to improve system performance in that the potential exists to increase both repeater spacing and information capacity. If the local oscillator has sufficient optical power, the coherent optical communication system can be advantageously limited by shot noise rather than thermal noise. A PIN diode is sufficient for coherent detection and no avalanche photodiode (APD) is needed. This feature is very useful in the long wavelength region (1.2-1.6 μm), because low noise APD's are not presently available.

Direct frequency modulation (FM) in semiconductor diode lasers was being studied both experimentally and theoretically. A 300-500 MHz modulation in optical oscillation frequency is achieved in a channeled substrate planar stripe (CSP) laser or transverse junction stripe (TJS) laser with less than 10% modulation in optical intensity (or driving current). The FM response is dominated by an active layer refractive index change induced by injected carriers. Refractive index change, in the active region, associated with a carrier induced temperature change, is believed to be responsible for "FMing" less than 10 MHz, while refractive index change due to carrier plasma oscillation and carrier induced band edge shift is responsible for FM deviations greater than 10 MHz.

If spectral purity and long-term wavelength (or frequency) stability is practically achievable, then the coherent optical detection system (via mixing with the local optical oscillator) will be about 20 dB more sensitive than an incoherent direct detection system. In practice, for a 200 Mbit/s FSK heterodyne detection experiment performed at NTT, an advantage of only 2 dB was measured. The difference between theory and experiment is believed due to FM noise, which is associated with spectral impurity in both signal and local optical waves. Three main contributions to FM noise are spontaneous emission, carrier noise (via thermal, plasma oscillation, and band edge effects), and thermal fluctuation in current. To improve the spectral purity of laser diodes in coherent optical communications, a laser with 900 μm cavity length (ordinary laser cavity length is 300 μm) is utilized. The improvement in spectral purity is due to high Q cavity provided by longer cavity length, which has less optical reflection loss per unit length.

NTT's interest in coherent optical fiber communication is related, in part, to their effort in increasing repeater spacing for long-haul wideband submarine communication links between Japan and Hawaii. This trans-Pacific fiber optic link will operate at 100 Mbit/s or 400 Mbit/s with a projected repeater spacing greater than 50 km. The cable to be used will have four-six fibers/cable. The projected operational date of the trans-Pacific telephone link is expected to be around 1988.

Dr. J. Sakai talked about the research on "twisted single mode optical fiber as a polarization-maintaining fiber." Preservation of polarization of light waves is important in the coherent optical communications applications, connection with single mode optical waveguide devices, and single mode fiber optic sensors. Single mode optical fibers with large birefringence can preserve the polarization state of the input optical wave during its propagation through the fiber.

A twisted single mode fiber shows a high degree of polarization for any polarization state when phase compensation is performed at the fiber output. This polarization-preservation property is probably the result of averaging fiber irregularity due to the presence of fiber twisting. Thus, it does not need precise alignment of the polarization plane in fiber mutual splicing. The polarization maintenance characteristics are stable even under the influence of external perturbation on the optical fibers. It was determined that a single mode optical fiber of 1.14 km with a twist rate of 2 turns/meter preserves the electric field polarization state. A small dispersion unit is measured to be around 2 ps/km for the mentioned twist fiber. The polarization dispersion is the difference in pulse transit times between two orthogonal polarization states in single mode optical fibers.

A laboratory tour of the molecular beam epitaxy (MBE) facility at NTT Musashino was led by Dr. H. Okamoto. MBE is one of the most versatile techniques for growing epitaxial layers on the semiconductor substrate. The substrate is held in an ultrahigh vacuum environment while molecular or atomic beams of constituents impinge upon the substrate surface. The rate at which these atomic beams strike the surface can be closely controlled, and growth of the high quality epitaxial layer results. Any desired compositional and doping profile can be obtained by controlling shutters in front of individual beams. The MBE method is capable of growing atomically smooth ultrathin (200Å) epitaxial layers and heterostructure interfaces of very high quality.

The MBE facility we were shown was made in Japan, and is an improved version of the MBE equipment manufactured by Varian Associates. It had the advantage of permitting the changing of substrates inside the ultrahigh vacuum environment during the epitaxial growing process. Eight vacuum evaporation cells are inside an ultrahigh vacuum chamber to direct beams of Al, Ga, As and dopants on a GaAs substrate. The slow growth rate of 1 atomic layer/sec is achievable. Epitaxial layer thickness can be controlled by shutter with 1 sec time resolution. Diagnostic equipment with a 1.04Å resolution associated with the MBE facility shows that no lattice disorder of the heterostructure growth can be seen.

Multiquantum well (MQW) heterostructure laser diodes were fabricated by the MBE process. The MQW laser was composed of eight GaAs quantum well layers and undoped $Ga_{0.83}Al_{0.17}As$ barrier layers. Thickness of the quantum well layer and barrier layer were 105Å and 80Å, respectively. The cladding layer was $Ga_{0.7}Al_{0.3}As$. Threshold was 94 mA for a 10-μm-wide and 200-μm-long stripe geometry MQW laser diode.

As compared to conventional double heterostructure (DH) lasers, MQW lasers are characterized by low threshold current density, less temperature dependences of threshold current, and better dynamic properties. Using the above MQW lasers, NTT reported the first observation of large differences in optical gain between TE and TM polarizations. At driving current equal to threshold current, the gain difference between TE and TM is 120 cm^{-1} and 20 cm^{-1} for MQW and conventional DH lasers respectively. This implies that it is possible to obtain polarization stable light sources from MQW lasers.

A large difference between ionization coefficients for electrons and holes is needed for low noise, high speed APDs. Bell Laboratories demonstrated experimentally that in a superlattice with 50 alternating heterostructure layers of $Ga_{0.55}Al_{0.45}$ and GaAs, the effective ionization rates for electrons and holes are very different, even if the ionization rates are the same in the bulk material. The physical reason for the large difference in ionization rates is the significant difference in the band discontinuities for electrons and holes at the heterostructure interfaces (E_C=0.45 ev and E_V=0.08 ev). This effectively reduces the impact ionization energy for electrons but not for holes, thus the ratio of ionization rates is greatly increased.

NTT Musashino was also interested in this artificial increase of ionization ratio between electrons and holes for the purpose of manufacturing solid state photomultipliers or APDs with minimum excess avalanche noise. This APD superlattice with enhanced ionization ratio will be grown by the MBE process.

FUJIKURA ELECTRIC COMPANY

Our survey of the Japanese fiber optics technology base began at Fujikura's Sakura plant. Prior to our visit we had not had much exposure to Fujikura as compared to Sumitomo and Furukawa Electric.

We were hosted by Mr. Akira Okano and Mr. Ryozo Yamauchi at the Sakura plant, which is the primary optical fiber facility for this company. A brief background was presented on the company in terms of its involvement in fiber optics. Fujikura started research and development of optical fibers back in 1972 and progressively lowered the attenuation in the fiber, year by year, until 0.2 dB/km was achieved at the 1.55 μm wavelength. In the course of the briefing, it became clear that Fujikura, Sumitomo Electric, and Furukawa Electric conducted much research and development in the fiber optics area in a cooperative arrangement guided by NTT (Nippon Telegraph and Telephone). Their cooperative efforts produced the VAD (vapor axial deposition) process which allows them to manufacture very large preforms of high quality. Fujikura's production and marketing seems to be targeted for the Japanese domestic markets. In our discussions they mentioned that much of their production was presently devoted to supplying the NTT trans-Japan trunk line project. For this project a span of 3,000 km was to be connected using a 50 fiber, single mode (SM) cable design. A transmission rate of 400 Mbit/s is planned, providing 5760 channels. At intermediate junctions, graded index (GI) fibers will be installed, operating at 32 Mbit/s and 100 Mbit/s. Design and planning at the local level is not yet complete or clear. Apparently, NTT is also experimenting with subscriber service systems that would provide television as well as telephone communications. The trunk line, however, is due to be fully installed by the end of 1984.

Fujikura is also involved with Kokusai Denshin Denwa, Ltd. (KDD) in developing a fiber optic cable for a trans-Pacific installation spanning Japan to Hawaii. A request for proposals is expected by 1986, with completion of the project due by 1988. The telemetry system will operate at 100 or 400 Mbit/s and use a four or six fiber cable.

Besides these two major projects, the Fujikura spokesman mentioned that there is work ongoing with power distribution companies such as Tokyo Electric Power and subway and rail transport companies. Their international standard graded index fiber utilizes a core/cladding geometry of 50/125 μm with an index difference of 1%. The primary buffer coating is a silicone RTV to a diameter of 0.4 mm with a secondary coating of Nylon-12 to 0.9 mm. They mentioned that they thought they could reduce the outer diameter of the buffer coating to 0.6 or 0.7 mm and still maintain good performance. Fujikura can make fiber with the MCVD (modified chemical vapor deposition) or VAD (vapor axial deposition) process, however, there seemed to be more effort directed at VAD work from what we saw. Their graded index product has a typical attenuation of 0.6 dB/km at 1.3 μm and a bandwidth-length product of 800 MHz/km. The standard proof test is 0.5%.

After the introductory briefing, we were given a tour of the fiber manufacturing facility. We saw preforms being manufactured under the VAD process which yields finished preforms of very large volume. The preform is dehydrated in a chlorine gas atmosphere and then consolidated at high temperature. The preform typically is reduced to half of its original diameter and half of its original length at this point. Apparently two major advantages of VAD are the ease of creating very large preforms and the ease of removing water from the glass. During drawing, the preform is melted down through a constant temperature carbon furnace. The diameter of the glass fiber is monitored with a laser scanner and the draw speed is varied to adjust the diameter. Downstream, silicone is applied to the glass through a metal die that is servo-driven to control the eccentricity of the coating. When asked about low modulus UV-cured polymers, Fujikura responded by saying that work was ongoing but that materials as soft as present silicone materials had not been found yet. When asked about the reasons for using Nylon-12, they said that it had been selected because the draw down ratio was not critical and therefore was easier to work with.

At the conclusion of our visit we found out that their United States marketing is handled by the C. Itoh Company, which is a Japanese trading company. This tends to support our earlier impression that Fujikura is not as committed to foreign markets as is Sumitomo and Furukawa, which have set up dedicated marketing organizations in the U.S.

FUJITSU LIMITED

- Kawasaki Plant

There are 37,300 employees in 12 plants within the organization of Fujitsu, Ltd. The locations of these 12 plants are Kawasaki, Aizu, Kanuma, Oyama, Kumagaya, Minamitama, Nagano, Suzaha, Nasu, Akashi, Numazu, and Iwate. Fujitsu is the largest computer manufacturer in Japan. The Japanese name "Fujitsu" means "Fuji Communication" in English. Indeed, Fujitsu is a leading supplier of telecommunications systems and equipment. In addition to computers, telecommunication systems, and related equipment, Fujitsu is also a major producer of semiconductor and advanced electronic components.

The NOSC team visited only the Kawasaki plant, which is located about 15 miles southwest of Tokyo. We were hosted by Mr. M. Kosai, assistant manager of the transmission systems department. There are about 200 professionals working on the design of optical fiber transmission systems and about 75 technical personnel engaged in the research and development effort related to fiber optic communications.

Fujitsu began research and development in optical communications in 1962. The company provided optical communication systems for public communication, power plant communication, computer communication, broadcasting, CATV and various applications for industrial use. Fujitsu's optical cable transmission systems include repeater equipment and terminating equipment for telephone links. The North American Optical Fiber Cable Transmission System fabricated by Fujitsu is compatible with Bell System interfaces with bit rates from 1.5 Mbit/s (24 telephone channels) to 560 Mbit/s (6048 channels), while the European Optical Fiber Transmission System has bit rates from 2 Mbit/s (30 channels) to 565 Mbit/s (7680 channels). Various optical components are fabricated by Fujitsu which are noted for their high performance and reliability. These include laser diodes, light emitting diodes, avalanche photodiodes (APD), PIN diodes, optical fiber connectors, optical attenuators, optical switches, optical couplers, and optical branching filters. Fujitsu is the only Japanese company that is currently mass producing Ge-APDs, which are sensitive in the spectral region including 1.3 μm and 1.55 μm, where both attenuation and dispersion are minimized for silica optical fiber. Both 1.3 μm laser diodes and Ge-APDs manufactured by Fujitsu have a rise and fall time of about 0.5 ns. We were informed that the speed of the laser diode is limited by the stray packaging capacitance, and the fall time of the Ge-APD is limited by the semiconductor minority carrier lifetime.

Based on their experience in computer systems, optical fiber communication systems, and digital communication systems, Fujitsu has also developed local area network (LAN) systems which are commercially available. Voice and picture signals are carried simultaneously over optical fibers. One example of a LAN is the research information processing system (RIPS) which is utilized by 3000 researchers in the Tsukuba Research Center in the Tsukuba Science City in Ibaraki, Japan. The purpose of RIPS is to improve the computing facilities so that researchers can access data bases and perform technical and scientific calculations using a centralized large-scale computer. RIPS is also expected to promote interdisciplinary activities by sharing a common information processing system. There were 550 optical sources (0.83 μm LEDs and laser diodes) and Si photodetectors (PIN and APD). No failure of any these devices has been experienced over the past two years. Step index and graded index multimode optical fibers are used for indoor and outdoor runs respectively. The bit rates of this LAN are 0.77, 16.9, and 33.3 Mbit/s. Future improvement of data gathering and processing capability is available because signal processing can be incorporated at a later time if necessary.

In the near future, Fujitsu expects to increase research and development in long-haul wideband (400-1600 Mbit/s) systems and submarine optical cable transmission systems. The current state-of-the-art is such that most of the existing submarine transmission systems utilize coaxial cable. A number of important advantages have been identified for replacing the existing technology with technology based upon fiber optic communications. It is believed that the replacement of coaxial cable by optical fiber cable will start to take place by 1988.

FURUKAWA ELECTRIC COMPANY, LTD.

Furukawa Electric Company is one of the largest and most aggressive Japanese companies involved in the production of optical fiber and fiber optic cables, in addition to being a major supplier of nonoptical cables for the world market. The Japanese Corning Glass Works (CGW) MCVD licensee, Furukawa, is presently in full-scale production of optical fibers manufactured by VAD as well. Currently, the bulk of the current production of optical fiber is VAD-fabricated monomode waveguide for NTT. Additionally, a large amount of multimode, graded index fiber is being produced with both VAD and MCVD. Our tour included the production facility for MCVD, but excluded the VAD preform fabrication process.

We were escorted to Furukawa's Chiba plant by Mr. Nishikawa (from the New York office). At the plant, we met with Mr. Azuma, the general manager of Furukawa's research and development department in the fiber optics area. Present also were Dr. Okubo, now manager for all domestic engineering: Mr. Hada, production manager; Mr. Nishimura, materials research; and Mr. Fuse, expert regarding FRP-buffered optical fiber microcables. A complete plant tour (excluding VAD preform fabrication) followed. We were shown the MCVD preform fabrication facility (operated under license to Corning Glass Works, U.S.A.) and were informed that, at present, the total preform production rate was nominally equal to the installed fiber drawing rate. This was confirmed by the presence of numerous rolls of drawn, coated optical fiber awaiting extrusion, implying that the production bottleneck occurred between the drawing and extruding processes. Ironically, the actual fiber which we were shown being drawn at that time was coated with UV-curable epoxy-acrylate to avoid the requirement of subsequent extrusion. The latter coating was a De Soto, U.S.A. formulation similar or identical to that employed by Corning Glass Works. We were shown two 30-meter-high drawing towers employed to enhance the production drawing rate, as well as the optical characterization facilities. Standard fiber draw length is 10 km for MCVD and 20 km for VAD fibers. Nylon-12 extrusion is performed off-line and accomplished by pressure extrusion at a fairly high rate (approximately 1 meter per second!). Apparently, 900-μ-diameter Nylon-12 jackets can be extruded onto NTT-specification fibers with acceptable tolerances at this rate.

All of Furukawa's production facilities appear to be new. All processes have been highly engineered, automated, and computerized. Quality control procedures are extensive and predelivery optical fiber characterization (postdraw, postjacket and postdelivery attenuation; bandwidth, core/cladding dimensional tolerances, and numerical apertures are measured routinely on all production fibers) is very complete, performed intelligently, and documented automatically.

Highlights of the visit centered around the magnitude of Furukawa's commitment to optical fiber production (particularly monomode optical fiber) in the form of research and development, facilities investment, plant throughput, and the extensive use of automation and computerized techniques for production and optical fiber characterization. Most notable, however, was the nature of the highly competent and aggressive engineering staff which the company had dedicated to research, development, and production of their optical fiber products. The engineers and managers were not just willing, but anxious to be confronted with technical problems and challenges such as those which we presented. The contrast with the attitude which we normally encounter in U.S. industry in this regard is striking in that many of the most impressive attributes observed at Furukawa (admittedly, in our opinion) have been virtually absent in our dealings with U.S. companies.

HITACHI CENTRAL RESEARCH LABORATORY

- Kokubunji

Hitachi, Ltd., consists of the Central Research Laboratory, the Hitachi Research Laboratory, the Mechanical Engineering Research Laboratory, and 30 Hitachi factories. The Central Laboratory is the main facility for research and development in the organization of Hitachi. Located in Kokubunji (a suburb of Tokyo), this research facility was built without disturbing the natural beauty of the area. Within the peaceful environment of the Central Research Laboratory there are 800 scientists and engineers performing research in various fields such as physics, electronics, mechanics, chemistry, metallurgy, mathematics, etc. The total number of employees in this laboratory is 1200, with 200 professionals holding doctorates in either science or engineering.

Research and development activities within Hitachi are subdivided into nine departments:

- chemical and semiconductor materials and solid state physics,
- metallurgical, magnetic, and ceramic materials,
- materials and production process for LSI,
- scientific instruments (application of ion, electron, and light beams),
- telecommunications systems and devices,
- computer peripherals and information processing equipment,
- LSI device design,
- computer architecture and applications, and
- medical engineering and life engineering.

Because all of the four members of the NOSC team were interested in the field of fiber optics, we visited only R&D activities in fiber optic components and systems. Our host was Dr. N. Chinone, who is working in the first department. The R&D in semiconductor diode lasers is conducted in the first department, headed by Dr. M. Nakamura, an internationally known expert in laser diodes. There are 25 people working for Dr. Nakamura, with 15 researchers and 10 technicians. In the fiber optic component industry, Hitachi is famous for their pioneering development in channeled substrate planar stripe (CSP) lasers. This weakly index-guided CSP laser involves one step epitaxial growth of the light-guiding layer. Its outstanding feature is its ability to consistently operate with single longitudinal mode conditions under dc drive.

The Japanese emphasis on developing distributed feedback lasers is also evident by injection laser research at the Hitachi Central Research Laboratory. It is well-known that single mode silicate fiber has a minimum attenuation of approximately 0.2 dB/km at 1.55 μm; but that the material dispersion minimum typically occurs at approximately 1.30 μm. A residual material dispersion of about 17 ps/(km/nm) is associated with such a 0.2 dB/km fiber at 1.55 μm. It is possible to shift the minimum dispersion wavelength from 1.30 μm to 1.55 μm by cancellation of material dispersion with waveguide dispersion. This in turn can be achieved by increasing the waveguide dispersion with a high relative index difference. The price paid for this dispersion optimized fiber at 1.55 μm is attenuation greater than 0.2 dB/km due to Rayleigh scattering associated with higher relative index difference, thus negating many of the advantages of using 1.55 μm in the first place. It makes sense to take advantage of the minimum attenuation of 0.2 dB/km obtainable from the fiber at 1.55 μm and to minimize the pulse dispersion by using single longitudinal mode 1.55 μm laser sources. Under high speed modulation, typical Fabry-Perot laser diodes exhibit multilongitudinal mode emission. This can cause overall system bandwidth reduction in a single mode communications link compared to the potential link bandwidth. The distributed feedback (DFB) laser can operate in a single longitudinal mode under narrow pulse operation. Hitachi's DFB laser development is aimed at single mode operation at 1.55 μm with distributed feedback built into the InP guiding layers.

The Hitachi Central Research Laboratory has been strongly interested in the transverse mode stabilized high power laser for use as a light source for optical information processing such as laser beam printers and optical disk direct reading. To meet this need, GaAlAs high power visible lasers with a self-aligned stripe buried heterostructure (SSBH) have been developed. SSBH lasers have a wide waveguide layer which is self-aligned to the narrow active layer. Stable oscillation in the fundamental transverse mode up to about 50 MW of output power at wavelengths around 780 nm have been reported. Growth of the short (visible) wavelength GaAlAs is not an easy task, since the second liquid phase epitaxial growth having high AlAs composition is difficult.

Optical electronics integrated circuits (OEIC) is also an active research area at Hitachi. OEIC research is conducted in many industrial laboratories and is coordinated by the Optoelectronic Industry and Technology Association established by the Ministry of International Trade and Industry (MITI). In the Hitachi Central Research Laboratory, one laser diode, one photodiode, and six GaAsFETs are monolithically integrated to form a laser transmitter. Six GaAsFETs and a photodiode are fabricated on one GaAs chip, which is to be used as a laser driver.

Investigation is also in progress on fabrication of 1.3 μm light emitting diodes (LEDs) for high speed operation in the 200 MHz to 300 MHz region. It is found that the rise time of an LED is about 2 to 3 ns and the fall time is about 10 ns. It is speculated that the difference in rise and fall times is due to current spreading. As the current density falls, carrier recombination time will increase since it takes a longer time for recombination between electrons and holes to take place at a low carrier density.

The most popular Hitachi laser structures are the buried heterostructure (BH) and the channeled substrate planar stripe (CSP) laser. The BH laser is an index-guided device, while the CSP laser is a weakly index-guided realization. Another laser structure is the modified channeled substrate planar stripe laser (MCSP), which is an index-guided laser. The main difference between BH and MCSP lasers lies in the manufacturing procedure. The BH laser needs two-step epitaxial growing processes, while a one-step epitaxial growth process is sufficient for MCSP laser fabrication.

The research activity in guided wave optics is conducted in the second department with a staff of about 18. Single mode polarization-preserving fiber manufactured by Hitachi has a loss of 0.8 dB/km at 1.55 μm. The extinction ratio between two orthogonal polarizations is 30 dB. We were shown a length of this optical fiber incorporated into an optical fiber gyroscope. The interference fringe pattern in the experimental gyroscope is stable even under perturbation caused by a finger touching of the elliptical (polarization preserved) fiber. An integrated optical switch operated at 1 MHz was also demonstrated with an extinction ratio somewhat less than 20 dB. Optical isolators with 20 dB extinction ratio have also been built experimentally. Sol-Gel fiber has been fabricated with an attenuation of 20 dB/km.

Development of optical communication systems is undertaken in the fifth department with approximately 13 scientists and engineers. Duplex analog CATV transmission was experimentally demonstrated in the laboratory using wavelength division multiplexing over a single fiber of 2 km length. For transmitting command signals and video signals to subscribers, 0.81 μm and 1.3 μm lasers were used, while a 0.89 μm laser was utilized for transmitting request signals from subscribers.

KOKUSAI DENSHIN DENWA, LTD. (KDD)

Kokusai Denshin Denwa, Ltd., (KDD) (literally translated: "International Telegraph and Telephone Company") is the Japanese company which is responsible for overseas communications via satellites and ocean cables. KDD is interested in implementation of fiber optics in transoceanic cables to increase channel capacity in future installations, and in remote controlled ocean vehicles using fiber optic tether cables for telemetry for inspection of ocean floor cable installations. KDD works closely with the Nippon Telegraph and Telephone Company (NTT) (responsible for domestic TELCOM) and Ocean Cable Company (OCC) (developer and manufacturer of transoceanic fiber optic cables).

We visited KDD as members of a tour group arranged through IOOC '83 (International Conference on Integrated Optics and Fiber Optics Communication '83). We visited the KDD Central Research Laboratory in Tokyo, where we met with the public affairs officers of the company.

Highlights of the tour included a look at an undersea remote controlled vehicle used for inspection of implanted ocean cables. This vehicle used a rather large diameter (approximately 3 cm), heavy cable approximately 500 meters in length as an umbilical. The cable contained eight graded-index optical fibers, of which only one was employed for communications; the remaining fibers were "spares." Additionally, numerous electrical conductors for signal and power transfer were contained within the cable. The system included a rotary joint at the surface-mounted take up drum and an analog television transmission system. Plans are underway to convert the communications to full duplex operation employing wavelength duplexing techniques at 0.65 μ and 0.83 μ.

We were also shown developmental quaternary APD's (avalanche photodetectors) and DFB (distributed feedback) injection lasers operating at 1.53 μ. The latter was an in-house development. Use of these components will permit high-bandwidth link operation with maximum repeater spacing in subsea telephone systems. Tentative plans call for a transoceanic cable which supports two optical links in each direction, containing single mode optical fiber. Each link would operate at 400 Mbit/s data rate. The goal for interrepeater spacing is 50 to 100 km. Deployment would begin in 1986, with operation commencing in 1988.

A read/write/erase optical disk system was also demonstrated during the visit. The disk uses magneto-optical effects to store and retrieve large amounts of data. A rotating disk coated with magnetic material poled in one direction can be selectively poled in the opposite direction by simultaneous application of a magnetic field and a laser pulse for writing. The laser pulse causes localized heating of the magnetic material above the Ci temperature. Reading makes use of the Faraday effect which is induced upon a second laser beam directed at the surface of the disk. The 10 cm diameter disk used in the prototype system is said to be capable of storing over 10 Gbits of data.

NIPPON SHEET GLASS COMPANY

Nippon Sheet Glass Company (NSG) is one of three major Japanese suppliers of bulk soft glasses and soft glass products such as plate glass, windshields, and fiberglass. Of particular interest in a fiber optic context is their line of graded index microlenses, known as SELFOC, manufactured by NSG. These SELFOC lenses play an important role in many fiber optic peripheral devices such as couplers, connectors, and multiplexers including several such devices developed by NOSC. Additionally, NSG manufactures a line of medium-loss optical fibers for short distance communications applications such as local networks.

We were escorted to NSG in Sagamihara (near Kawasaki City) by Mr. Mizuta of the Clark, New Jersey, engineering office of NSG. At the plant we met with Mr. Koizumi, general manager of the fiber optics products division, and Mr. Iwao and Mr. Akazawa, manager and senior engineer respectively of the SELFOC production operation. We were escorted on a full plant tour by the staff and were shown the bulk glass melting and drawing process and the ion exchange process employed to form a quadratic refractive index in the rods. The latter is based upon immersion of the borosilicate rods in a molten thallium salt solution for extended periods of time to modify the glass properties in a reproducible manner. We were subsequently shown the assembly process for the

SELFOC lens array (used in office copier machines), cutting, lapping, and polishing operations and measurement and quality control processes.

Of particular interest was the use of extensive, multiple quality control procedures between each of the manufacturing operations (something which we have rarely seen in U.S. manufacturing), and the use of an industrial robot for final MTF verification of SELFOC lens array performance. Of significance was the extremely low overall final part rejection rate (only a few percent), uniform piece-to-piece performance (which we have indeed observed in the case of SELFOC products) and automatic parts documentation.

We were notified of several impending actions which will be undertaken by NSG in the near future: a plant is to be opened soon in New Jersey in 1984 to produce SELFOC rod lenses targeted at the American Telephone and Telegraph Corporation market. This plant will be even more automated than the Japan facility. Mr. Iwao expressed concern that the quality of the American workers to be employed at the U.S. facility might tend to preclude high quality output, hence the total number of workers will be held to three to five! Robots will provide nearly all of the "skilled labor." We were informed that the cost of SELFOC microlenses in the 0.25 pitch length would continue to decrease in the future to perhaps $2 apiece (presently, the cost is $20-$30 each). The reduced costs will result from increased demand and corresponding production, as well as increased automation as new manufacturing facilities come on-line. Three new SELFOC products are scheduled for release this fall: a microlense optimized for monomode connector use, a very high NA microlense (NA = 0.6) and a metallized microlense for hermetic sealing applications. Related to the latter, Mr. Koizumi recommended that in applications such as the NOSC penetrator, which are intended to be exposed to moisture for extended periods, metallic-coated rod lenses with endfaces passivated with some material such as silicon nitride can be employed to increase long-term reliability.

Highlights of the visit included the overall scope of SELFOC product manufacture from raw materials through finished devices undertaken by NSG. Most impressive were the extensive quality control procedures imposed between intermediate production steps to maintain process control within strict tolerances and to prevent defective pieces from migrating upwards toward final inspection where they would be rejected. We have seldom observed quality control procedures so pervasive at any U.S. manufacturer (final inspection, if any, is the basis for pass/fail) because of the high costs involved. Mr. Iwao informed us that such procedures are employed to keep the production yield high, thus ultimately driving the cost down. We also had an opportunity to witness the use of an industrial robot for final inspection of the SELFOC lens arrays and the existence of an extremely complete and modern optical laboratory which is employed for ongoing product characterization and improvement.

SUMITOMO ELECTRIC INDUSTRIES, LTD.

Sumitomo Electric is the largest of the "big three" optical fiber manufacturers in Japan. Sumitomo along with Furukawa Electric, Fujikura, and NTT, cooperatively developed the VAD (vapor axial deposition) process for the manufacture of optical fiber preforms. Sumitomo was the leading contributor for the development of this process and as such was awarded the major share of NTT's Japan trunk line project which has already started and when finished at the end of 1984, will provide an optical communications trunk line from Hokkaido in the north to Kyushu in the south. (See Fujikura, Ltd., discussion).

We were hosted by Dr. S. Takeuchi, and he began with a comprehensive description of Sumitomo Electric. Like the other Japanese fiber manufacturers, Sumitomo's prime product lines were initially copper wire products. Their product lines have expanded and now encompass fiber optics, steels, metallic materials for electronics, disk brakes, rubber and plastics, and III-V compounds for semiconductors. Since the major field of interest for our group was fiber optics, Dr. Takeuchi then had Mr. Oshima and Mr. Hoshikawa report on the results of their current developmental efforts with optical fibers. Mr. Oshima is currently developing a small diameter, GI telecommunications fiber. The fiber uses a standard 50/125 core/cladding geometry and accepted glass chemistry/index profile design. The difference lies in the buffer coatings applied over the glass after it has been drawn. Standard GI telecommunications fibers used in Japan have a silicone resin primary buffer coating applied to a 400 μm diameter. Over this inner coating, a secondary coating of Nylon-12 is applied to a 900 μm size. The Nylon-12 coating makes the fiber easy to handle and provides some abrasion resistance. Silicone is applied in-line during the drawing process and protects the surface of the glass against contamination and scratching. The combination of Nylon-12 and silicone buffers also has shown very good resistance to excess loss when lateral forces are exerted on the buffered fiber as might be the case when packaging it into a telecommunications cable. One drawback of this buffering design has been a susceptability of the fiber to exhibit high excess loss as the ambient temperature is dropped. The Nylon-12 material contracts as it is cooled and causes a buckling of the optical fiber. Presently, cabling companies compensate for the temperature effect by incorporating a high tensile modulus, low expansion, strength member in the cable structure. The strength member then restricts the contraction of the Nylon-12 and solves the problem. The small diameter fiber project at Sumitomo is targeted at examining new materials for the buffer coatings which will allow the fiber itself to be naturally insensitive to temperature and pressure fluctuations. More importantly, it is hoped that UV-curable polymers can be used such that lower production costs can be realized. If successful, use of UV-curable polymers will allow elimination of a complete processing step (Nylon-12 extrusion) and also allow faster draw rates.

Use of UV-curable polymers as buffer coatings for optical fibers is not a new idea. All U.S. fiber manufacturers, including Corning and Western Electric, use such materials in the United States and it is well-known that ATT is paying only 30 to 40 cents/meter for their fiber. Unlike the U.S. companies, however, Sumitomo's UV-curable work is directed at producing a fiber that can be used in more hostile environments and thus is aimed at a broader application market. Mr. Hoshikawa proceeded next to summarize work that has been done on characterizing single mode fiber production for both VAD and MCVD processes.

It should be noted that in the U.S., OVD and MCVD are the primary production processes whereas in Japan the preferred method is VAD. Primary advantages suggested by Sumitomo of VAD over MCVD was ease of dehydration of the preform and the ability to make large preforms. Typically 50-80 km preforms are made and drawn and fiber is then cut to 15 km lengths for measurement. Data was presented on 100 km continuous fiber made with VAD and sectioned into six equal lengths. The attenuation, cutoff wavelength, core diameter, and core eccentricity was measured and appeared to be very uniform for all of the sections. Statistical data was also shown for splice losses for identical fibers with a 8 μ core. Average loss was 0.07 dB with a standard deviation of 0.04 dB and a sample size of 100. Splice losses for single mode cable spliced in the field was also presented with an average loss of 0.13 dB and a standard deviation of 0.05 dB with a sample size of 96. For both cases, the power through the fiber was monitored for alignment purposes. Various single mode fibers were also fabricated with zero dispersion wavelengths varying from 1.3 μ to 1.54 μ. Sumitomo is experimenting with fiber designs

to allow zero dispersion at wavelengths other than 1.3 μ and also possibly a double dispersion minimum window fiber. Some work on fiber splicing was also reported where significant improvement occurred through the use of a HF etching treatment. The final area of discussion dealt with a review of the work that has been done with the VAD process to improve the strength characteristics of production optical fiber. Sumitomo's technical staff presented data that suggested a high drawing temperature and low draw tension contributed to higher strength fiber. In addition, various materials used in fabricating the preform were compared with a fire-polished synthetic quartz tube over a synthetic quartz core producing the best results. The negative effect of surface flaws on the preform was also experimentally confirmed. Our visit was concluded with a tour of the manufacturing facility. We were shown both single mode and multimode fiber preforms being made with the VAD process. The process itself was highly automated with one operator monitoring five machines. It was apparent that great attention was paid to cleanliness. After the preform is fully deposited, it is sintered and dehydrated in a chlorine gas environment and collapsed to a solid, transparent core rod. The rod is then inserted into a Hiraeus silica tube and collapsed into a finished preform. These preforms are then dried and later measured. Currently, fiber drawing is done using carbon furnaces with in-line flow coating of silicone resin as the primary buffer. The drawing speed is presently limited by the use of silicone resin as the buffer coating material. Once drawn, the fiber is measured optically on the storage spool and then later the outer layer of Nylon-12 is extruded over the primary buffer of silicone. Once Sumitomo completes development of a UV-cured buffer coating design, production speed could be potentially 10 times faster.

OPTOELECTRONIC INDUSTRY AND TECHNOLOGY DEVELOPMENT ASSOCIATION

As stated in their charter, the Optoelectronic Industry and Technology Development Association (OITDA) is a consortium of industrial companies which was established in 1980 with the goal of promoting research and development in optoelectronic technology. The scope of R&D activities of OITDA is very broad and includes such areas as forecasting marketing trends to total systems development, feasibility demonstrations, and standardization of components and systems.

The NOSC team visited the headquarters of OITDA on 23 June 1983 where Dr. Mashiro Hirano, director, served as host. The customary briefing revealed that the association currently has 145 supporting companies although, when established, there were only 11 founders, represented by such large and powerful enterprises as NEC, Hitachi, Fujitsu, Sumitomo Electric, etc.

The association views optoelectronic technology as being comprised of two elements: information-based technology and energy-related technology. These two subareas are further divided, as one may predict, into more detailed classes. Each of the subspecialties is represented by a steering committee composed of representatives from the various member companies. It was not clear how many members were on each committee, but it is unlikely that all 145 member companies are equally represented considering the broad scope of the association's charter. More than likely, companies participate in only those areas of direct interest to their own business. As part of the activities of the association, a joint research laboratory in optoelectronics has been established. The present staff of the laboratory numbers about 50. Established in Kawasaki in late 1981 by the Ministry of International Trade and Industry (MITI), the R&D activities are directed in support of the optoelectronic integrated circuits (OEIC) effort, one of the subspecialties of the association's charter.

The work on OEIC has three main subtasks:

- R&D to produce high quality In P and GaAs substrates,
- epitaxial growth by various means (LPE, VPE, MBE, OMCVD, and maskless ion beam implantation) for fabricating integrated circuits, and
- detailed crystal morphological and analytical characterization.

Research is heavily oriented towards device integration in order to reduce costs and improve reliability and quality control. Although the U.S. community involved in the development and application of optical and electronic devices is convinced that integration is important, the much heavier emphasis shown by the Japanese government, industry, and the association is breathtaking. It must be noted that these are national goals established in harmony with the member companies of the association. The OEIC project is just getting underway, but the vision downstream includes the wide use of optical, as well as electrical, interconnects with VLSI circuitry.

Another R&D effort receiving heavy government funding is the optical measurement and control system. This project seeks to develop the technology for measurements, transmission of data, and remote or robotic control using optical fibers and lasers. The project is funded at a level of 18.0 billion yen ($40.0 million) over an eight-year period. The scope of the work appears to be general, but includes R&D on imaging data subsystems, data processing, and data control. The products resulting from this effort would be available for modernizing and upgrading manufacturing facilities, hospitals, office buildings, and educational facilities. The subtechnology issues are heavily dominated by optoelectronics, fiber optics, optical waveguide devices, optical sensors, injection laser diodes, VLSI, and magneto-optic devices.

Unfortunately, we were unable to visit the association's laboratory facilities to view their work in detail. Dr. Hirano provided full color brochures and pamphlets which only covered general topics. Nevertheless, the briefing and these documents provided some insight into the powerful and revolutionary consortium concept which has been so effective in helping to bring Japan to the forefront as a technological superpower.

Another project receiving considerable support is the application of optical technology to the steelmaking industry. Following the OPEC oil boycotts of the 1970s, the Japanese government, in cooperation with industry, embarked on drastic steps to reduce energy consumption. Steelmaking plants in Japan were already very modern at that time with extensive automation and process control. But by further upgrading the control system with fiber optics, benefits could be realized in reliability, energy consumption reduction, and EMI immunity. A large-scale feasibility demonstration of the concept was implemented in a plant of the Nippon Steel Corporation at Kimitsu in 1980. The system consists of an optical fiber data highway 4.2-km-long operating at wavelength 0.85 μm with a 10 Mbit/s data rate connecting casting plants, a degassing plant, and control computers. Although the system is under the charter of OITDA, it is actually implemented through joint efforts of Nippon Steel and Hitachi, Ltd.

The OITDA is also involved with other demonstration systems, including building management, powerline security, and monitoring in electric power plants, and fiber optic subsystems for local area networking systems. The formation and support of the association by the Japanese government has no parallel (yet!) in the U.S. Its impact on high technology insertion and utilization can only further strengthen Japan's competitive status in the world markets.

CONCLUSIONS

By the time this article goes to press, many of the topics described above will have, undoubtedly, advanced considerably. Already, some of the research we observed is beginning to appear in the technical literature. Nevertheless, it is hoped that this article is useful as a "time capsule " of our observations of the status of fiber optics in Japan in the summer of 1983 and serves as a starting point for those who wish to further pursue these subjects.

Although Japan has a substantial home market for fiber optic systems, it is clear that industrial leaders have their eye on larger horizons, including the U.S. market. Several companies are in the process of building manufacturing facilities in the U.S. For several years now we have observed a proliferation of quality, low cost Japanese fiber optics components in the U.S. It is our impression that the Japanese industry spans a large number of companies and universities, but that it possesses a depth which exceeds that of U.S. activities. Although the U.S. involvement is large and growing, it has suffered from dilution and lack of depth except for a few very large companies. The Japanese seem to have the advantage of exceptionally well-trained and qualified staffs, long-term employment stability with little turnover, adequately equipped laboratories and concerned, participative management. These conclusions are not unlike those observations of other industries as is widely publicized in the U.S. press. However, it was an enlightening experience for us to compare such activities in our own areas of specialization.

ACKNOWLEDGEMENTS

We wish to thank Dr. Sachio Yamamoto and Mr. Seikoh Sakiyama of the Office of Naval Research, Far East, for their assistance during our visit to Japan. In addition, we appreciate the support and encouragement of the Chief of Naval Operations and Naval Air Systems Command for partially financing the trip.

MARINE SCIENCE AND OTHER RESEARCH PROGRAMS AT THE ORSTOM RESEARCH CENTERIN NOUMEA, NEW CALEDONIA

Wayne V. Burt

INTRODUCTION

ORSTOM, the French Overseas Office of Scientific and Technical Research (Office de la Recherche Scientifique et Technique Outre-Mer) consists of the headquarters office in Paris and about 40 research centers and scientific missions, most of which are located in the tropics. The larger centers are concentrated in French overseas territories and former French colonies. Centers with over 100 personnel each are located in Noumea, New Caledonia; Dakar, Senegal; and Abidjan, Ivory Coast. Almost one-third of the smaller centers and missions are situated in the Caribbean and in South American countries.

The aims of ORSTOM are to develop and improve high quality research programs with the specific goals of contributing to the success of social, health, cultural, and economic progress in developing countries.

The ORSTOM center in Noumea was established in 1946. Its research groups are housed in a completely modern, air-conditioned building with 2600 m^2 of floor space. In addition to the laboratory building there is a 300-seat auditorium and 1300 m^2 of floor space devoted to offices and workshops. The center is located in the posh Anse Vata beach resort area on 20 acres of ground. U.S. World War II servicemen will remember the area as the U.S. military hospital and motor pool. Three-fourths of the over 200 individuals working at the center are scientists, engineers, and technicians.

For marine research, the center uses the 25-m-long converted trawler R/V *Vauban*, several smaller boats and Zodiac rafts. It is the principal user of the 37-m-long CNEXO vessel, the R/V *Coriolis*, which is based in the South Pacific. Occasionally, larger CNEXO-operated research vessels are also available for use by the center.

The research departments of ORSTOM make use of common facilities including: a large library, laboratories for chemical analysis, an electronic workshop, computer room, a photo laboratory, and drawing and cartography offices.

The Noumea center operates a small branch mission at Port Vila, Vanuatu (formerly the French-British condominium of the New Hebrides) with six to eight researchers and technicians in residence. The center also works closely with the 44-person ORSTOM center in Papeete, Tahiti, and a small mission in Indonesia.

New Caledonia is located about 1200 km east of Australia, midway between New Zealand and New Guinea. Its area, 19,000 square km, is a little larger than that of all the Hawaiian Islands and it is located in the trade wind belt about the same distance south of the equator as Hawaii is north of the equator. However, due to its rugged topography, isolation, and its soil characteristics and rainfall distribution, it has a population of only 140,000 people, less than one-twentieth of the population of the Hawaiian Islands. The main sausage-shaped island is oriented in a northwest-southeast direction. It is 400 km long and about 50 km wide.

A rugged mountain chain covers the center of the island from end to end. The long narrow area on the northeast, windward coast has a high rainfall. While limited in area,

it is well-suited to the production of coconuts, bananas, coffee, and other tropical fruits. The larger leeward southwest coast has a low rainfall and is primarily used as pasture land for beef cattle. Intensive cultivated agriculture is only possible in a few areas where there is sufficient water for irrigation and the soil is suitable.

New Caledonia is the world's third largest exporter of nickel and has 30% of the world's known reserves of this metal. Nickel and much smaller amounts of other products of mining make up almost all of New Caledonia's exports. This places much of the territory's economy at the mercy of fluctuations in the world price of nickel.

ORSTOM's New Caledonia and its island dependencies to the northwest, the nearby Loyalty Islands, and the more distant islands of Wallis and Futuna are all surrounded by vast ocean areas. Their potential for any major increase in the development of resources from the land is somewhat limited.

For the above reasons, the ORSTOM Research Center in New Caledonia is taking a keen look at all aspects of the oceans for their effects on man and for their known and potential resources. Marine study areas include shallow water lagoons, coastal waters, the deep ocean, the sea floor, and large- and intermediate-scale air-sea interactions. About one-half of the scientific manpower and resources of the center are now devoted to oceanography and marine geology and geophysics. This commitment by France to the study of the oceans and the sea floor around New Caledonia is, in proportion to the population of New Caledonia, one of the largest commitments in the world.

ORSTOM RESEARCH CENTER

- Oceanography

This is the largest department at the center and has 36 members. The head of the department, C. Rogers, was away during my visit. In his absence, I interviewed Y. Danndonneau, a former head of the department.

The premier research program at the center is the study of the hydroclimate: the connections between the oceans and the climate in the tropical Pacific, particularly near the equator in the southwest Pacific.

In order to study the largest possible area, the center uses volunteer observers on regularly scheduled cargo ships to gather oceanographic and meteorological data along the principal shipping routes to and from New Caledonia and Tahiti and major ports in the Pacific.

The program started in 1969. At first, water surface temperatures were recorded and water samples taken for salinity analyses at the center in Noumea. In 1977, chlorophyll sampling was added. The 20,000 samples that have been processed to date give a measure of the standing crop of small plants in the surface of the ocean and are rough indicators of the productivity. In 1978, an expendable bathythermograph (XBT) program was initiated. These instruments provide a record of the water temperature from the surface down to a depth of 460 m. At the present time, an average of 12 ships are making XBT observations for the center and are making a total of 300 XBT observations each year. This program is carried out in close cooperation with scientists at Scripps Institution of Oceanography and the National Oceanic and Atmospheric Administration.

The newest type of observation is made by French container ships that have swimming pools for their crews. Each night, the pools are drained and refilled with fresh sea water. The incoming water is filtered with plankton nets. The resulting samples are sent to New Caledonia for identification and enumeration of zooplankton that have been captured on the filters.

Much of the fluctuations that have been found in the temperature and salinity data for the tropical and equatorial Pacific are proving to be interannual rather than annual changes and appear to be correlated to worldwide interannual variations in climate such as the recent major El Niño of 1982.

It was first discovered in 1972, and then verified in 1976, that characteristic variations in near surface salinity occur in the western tropical Pacific in advance of El Niño situations that occur off Peru in the eastern Pacific. It was also confirmed that droughts in New Caledonia were related to El Niño situations and that the paths of typhoons in the southwest Pacific are abnormal during years when El Niños occur.

The "ships of opportunity" chlorophyll data may be used to infer variability in the productivity of the surface layers of the tropical Pacific in time and space over the routes where the samples were taken. The chlorophyll data for late 1982 and early 1983, during and following the major El Niño of 1982, clearly showed a decrease in the chlorophyll content over the whole tropical Pacific by the end of 1982. The exact cause of this phenomena has not been determined. It may be related to lack of normal vertical mixing and a decrease in the thickness of the near surface vertical mixed layer in the western Pacific.

The center has a major program on the biological productivity of the region around New Caledonia. They are endeavoring to relate the variations in productivity to changes in hydroclimatic parameters. For example, the local drop in productivity associated with the 1982 El Niño was followed by a major decrease in the tuna catch in waters east of New Caledonia.

It has been found that, in nutrient-poor regions of the oceans, the productivity around islands is enhanced. The center has mounted a major interdisciplinary study of the area around Mare Island, one of the nearby Loyalty Islands. Six cruises have been made to study the area. Data are being gathered on internal waves and currents, the chemistry and primary and secondary productivity around the island with the aim of constructing a mathematical model by 1985 that will take into account each of the factors affecting the primary productivity. So far it appears that internal waves, which are enhanced as they move into the shallow water around the island, may be one of the primary causes of the enhancement of the nutrients in the waters around the island.

One of ORSTOM's principal projects is lagoon research that is concerned with exploitable resources. The local pole-and-line tuna fishery is dependent on a steady source of bait fish that are netted within the lagoon. The research is aimed at managing and protecting this valuable resource. There is also a small fishery for *Trochus* shells that are used to make buttons and jewelery. Unfortunately, many of the fish found within the lagoon have flesh that is toxic to man due to the presence of ciguatera. A promising study is of the local fisheries concerned with fish caught at depths of 200 to 400 m on the outer face of the reef and which are free of toxins.

There are about 20,000 species of invertebrates that are living in the lagoon around New Caledonia. Extracts from samples of many of these species have been sent to France

where they have been examined for potential pharmaceuticals. Some components have been found in the samples that may be useful in the treatment of cancer.

- Geology and Geophysics

This department has 23 members stationed at the center in Noumea and an additional six to eight members stationed at its branch mission in Port Vila,Vanuatu. I interviewed the head of the department, J. Recy.

From 1947 to 1970, the geology and geophysics section carried out its research programs on land. The first few years were spent in making detailed magnetic, gravimetric, and geological observations in New Caledonia. Extensive earth sampling and geological prospecting for mineral depositions was done. Seismological and magnetic observatories were set up and maintained in New Caledonia, Vanuatu, and French Polynesia.

ORSTOM has a chain of 20 telemetering seismometers on the New Hebrides Island arc (Vanuatu) as part of a continuing study of this very seismologically active area. I was stationed for a time at Espiritu Santo in the New Hebrides during World War II. I have vivid memories of my cot dancing around on the raised wooden floor of the tent house where I slept during several earthquakes.

Since 1970 much of the research in the section has been concerned with marine geology and marine geophysics. Detailed studies have been made of the shallow coral reef area that surrounds New Caledonia. This is one of the larger coral reef areas in the world and covers an area almost as large as the state of Maryland. A geological study of the 200-mile economic zone around New Caledonia and its island dependencies has also been completed. In cooperation with scientists from other countries, ORSTOM scientists have made a thorough study of the ocean floor and earth's crust in the southwest Pacific. Studies include bathymetry, seismic reflection and refraction, bottom sampling, magnetic and gravimetric studies. Many of their results were published in 1982 in a large 649-page atlas, *"Contribution a l'etude Geodynamique du sud-ouest Pacific."*

Much of the research has been concerned with detailed mapping of the plate tectonics of an area about the size of Australia that is centered about New Caledonia.

The reasons for their large expenditure in time and effort are explained in the following paragraph which was taken from a recent ORSTOM pamphlet.

> The research, of which the above list is incomplete, once carried out, analysed, and published, is a basis on which to reconstruct the geological history of the southwest Pacific. Inventories can then be compiled that are the first indispensable step towards estimating the richness in minerals and energy that make up the potential of the region. We can then understand that the results of geological and geophysical research on land or sea carried out by scientists from Oceania, Australia, New Zealand, or the United States will affect part of the economic future of the southwest Pacific. In this region, one can state that the future is in the heart of the ocean.

- Hydrology

This department, which has 16 members, operates networks of rain gauges and streamflow gauges in New Caledonia and assists in the operation of a network of rain

gauges in Tahiti and Vanuatu. It analyzes data from the above gauges and publishes the results. Other studies include: the availability and suitability of water for irrigation; the potential for new hydroelectric projects (the main source of electric power for New Caledonia); and studies of water quality, including suspended sediment loads.

- Soil Science and Agronomy

These departments and other related departments are very important in their endeavors to help increase local food production. At the present time, despite its small population and relatively large area, New Caledonia must import a large part of its food, including livestock, cereals, and fruits and vegetables.

The Soil Science Department, which has 11 members, is primarily interested in mapping, classification, and cataloging soils according to their morphological, physical, and chemical characteristics. This study has been completed for Vanuatu and is underway in New Caledonia, Tahiti, Wallis, and Futuna. It also works with the Agronomy Department (which has three members) on soil fertility studies. These studies are based on fertility and growth rate tests, both in greenhouses and in the field. Their research efforts often face the problems associated with excess mineral contents of various kinds and concentrations in the soils that have adverse effects on the growth and productivity of agricultural plants. The aptitude of various soils is determined for agriculture, reforestation, and natural pasturage.

- Botany

This department, with nine members, has collected 50,000 samples of the flora of New Caledonia and Vanuatu and is preparing a publication on the flora of New Caledonia. Other studies include:

- the structure and dynamics of the forests,
- the dynamics of ecosystems that have been disturbed by man,
- the ecology of glasslands,
- inventory of the flora of Wallis and Futuna,
- regeneration of natural forests and reforestation in New Caledonia, and
- germination and conservation of seeds of trees of economic interest.

- Human Sciences

This department, which has nine members, is particularly devoted to social dynamics. Its main concerns are with the native Melanesians who make up almost half of the 140,000 inhabitants of New Caledonia. The adaptation of this largely rural segment of the population to the current environment, i.e., one dominated by a market economy which is now almost entirely foreign to the Melanesians, is the principal problem under study.

The Human Sciences section has contributed largely to the construction and publishing of a beautiful large atlas of New Caledonia. The atlas, which was published in 1982, is a cartographic synthesis of scientific knowledge of all kinds. The Human Sciences Department is divided into three divisions, geography, sociology and anthropology.

Studies in the geography division include:

- the geomorphology of the New Caledonian archipelago,

- the relationships between recent erosion and recent sedimentation in New Caledonia,
- the evolution of agricultural production and mapping charts of soil utilization, and
- natural hazards in French territories in the Pacific.

The latter includes preparedness and rehabilitation policies, the local distribution of risks, and the economic results of damage due to natural hazards.

Studies in the sociology division include:

- social dynamics of the Melanesian environment,
- the traditional society and contemporary social practices,
- risks of changing social practices, and
- the past and present role of religious forces in social changes.

Studies in the anthropology division include:

- the inventorying of New Caledonian stone carvings and determining the significance of their distribution,
- traditional native ceramics of New Caledonia,
- ancient relationships between New Caledonia and other southwestern Pacific Islands, and
- ancient limits of New Caledonian prehistoric culture and research on preceramics cultures.

- Entomology

This department, which has six members, maintains an ongoing inventory of plant pests related to agriculture. Its studies include:

- entomological problems related to raising animals, including the chemical control of cattle ticks,
- the feasibility of the introduction of insects that aid in recycling organic matters, and
- the combined use of biological and chemical agents in the control of plant pests.

- Pharmacology

This department, with six members, is making an inventory and study of land plants for potential medicinal drugs. These and other studies include:

- land plants that are traditionally used by the native Melanesians for medical purposes,
- chemical-pharmaceutical properties of medicinal plants,
- marine organisms of pharmacological interest, and
- determining methods of extraction and the chemical structure of natural substances from marine organisms.

- Plant Pathology

This department, with four members, studies: the pathology and epidemiology of specific diseases of agriculturally important plants such as orange rust in coffee, and fungal diseases of corn. It also inventories plant pests of interest in agricultural production.

Scientists, particularly in the fields of oceanography, marine geophysics, and geology and hydrology would find the OSTROM Center in Noumea a pleasant and profitable place to take a sabbatical leave.

For further information on ORSTOM activities in the South Pacific, write to:

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THE 15TH SYMPOSIUM ON ION IMPLANTATION AND SUBMICRON FABRICATION

Yoon Soo Park

The 15th Symposium on Ion Implantation and Submicron Fabrication was held on 1-3 February 1984 at the Institute of Physical and Chemical Research (Rikagaku Kenkyusho) at Osaka, Japan. The meeting is held annually in Japan and was organized by Professor Susumu Namba who is serving concurrently as director of the Microfabrication Research Laboratory at Osaka University and as head of the Laser Science Group at Rikagaku Kenkyusho. There were 49 oral presentations in Japanese. The purpose of the symposium was to bring together a number of scientists and engineers actively engaged in the fields of ion implantation and submicron fabrication to report on current research activities in process technology in Japan.

Papers presented covered a wide range of topics in the following categories:

- recrystallization induced by laser and electron beam,
- implantation in metals and semiconductors,
- transient annealing,
- focused ion beams,
- x-ray, electron and ion beam lithography,
- ion beam mixing.

There were two participants from the People's Republic of China and they presented a paper describing the development of semiconductor microfabrication in China.

Because of increasing interest and activities, papers dealing with transient annealing (in particular, lamp annealing) and focused ion beam technology will be discussed in this article.

TRANSIENT ANNEALING

Recently, transient annealing by a tungsten halogen lamp or a pulsed thermal anneal has received much attention as an alternative tool to repair the implantation-induced damage in the implanted layers of semiconductors and to activate implanted species in addition to laser or electron beam annealing. Because of its simplicity and the reduced redistribution of implanted impurities, many industrial laboratories in Japan are adopting this technique in lieu of the conventional furnace annealing. Many different types of annealing apparatus employing halogen lamps were displayed by various makers at the Semicon Japan '83 conference held in Tokyo on 1-3 December 1983. Several interesting papers dealing with lamp annealing were presented at this meeting.

"Short Time Annealing Characteristics of Ion Implanted AlGaAs/GaAs Heterocrystal by Tungsten Halogen Lamp." S. Tatsuta, *et al.*, Fujitsu Ltd.

Fujitsu, Ltd., employed the lamp annealing technique to create highly doped n-type layers for ohmic contacts grown by MBE. Ion implantation was used to produce highly doped n-type layers. Conventional furnace annealing after implantation resulted in

redistribution of the Si impurities in the selectively doped GaAs/N-AlGaAs heterostructure due to thermal diffusion which caused a decrease in the two-dimentional electron gas (2DEG) and an increase in the electron concentration of 2DEG. By employing the lamp annealing, these changes in the electrical characteristics of the heterostructure layers were greatly reduced. After lamp annealing at 900°C for 10 sec, the electron concentration and mobility at 77°K were found to be 4.8 x $10^{11}/cm^{-2}$ and 74,000 cm^2/VS, respectively, which were 94% and 73% of the "as-grown" samples. The lamp annealing can be effectively used to maintain the original properties of the heterojunction.

"Transient Annealing of Se-implanted GaAs." T. Ohfuji, *et al.*, College of Engineering, Hosei University.

Workers at Hosei University employed the transient annealing technique using a graphite strip heater in order to form a n^+ layer in Cr-doped, semi-insulating GaAs by implantation of 100 keV Se^+ ions to a dose of 5 x $10^{13}cm^{-2}$ at room temperature or 400°C. Postimplantation annealing was carried out on the samples encapsulated with pyrolytic Si_3N_4 in the same Si_3N_4 deposition chamber for 10 sec at three different temperatures of 900, 950, and 1000°C. Very high electrical activation and good profile integrity were obtained for both room and hot implantation when annealed at 1000°C for 20 sec. The maximum carrier concentration as high as 7 x $10^{18}cm^{-3}$ was obtained for hot implantation which is adequate for the ohmic contact region of GaAs devices.

"Annealing Characteristics of Si^+-implanted InP by IR Irradiation." F. Matsuoka and T. Itoh, School of Science and Engineering, Waseda University.

Waseda University workers used the infrared halogen lamp unit peaking at 1.15 μm to anneal Si^+-implanted, semi-insulating InP. Depth profiles of carrier concentration of 80 keV, 5 x $10^{13}cm^{-2}$ Si-implanted samples annealed at 900°C for 20 sec with a SiO_2 cap showed suitable agreement with the theoretical LSS profile. An electrical activation of 86% and a Hall mobility of 1000 cm^2/VS were obtained. In contrast, a furnace annealed sample at 750°C for 15 min gave an electrical activation of 70%. However, for IR annealing of longer than 20 sec, the activation tended to decrease due to surface decomposition. Detached investigations of electrical and mobility profiles as a function annealing time of between 7 and 30 sec revealed recrystallization processes promoted from both surface and interface sides.

"Deep-level Defects in Zn^+-implanted Transient Annealed GaAsP." T. Kozaki, *et al.*, Nagoya Institute of Technology and Aichi Institute of Technology.

Investigators at Nagoya Institute of Technology and Aichi Institute of Technology jointly reported the fabrication of shallow GaAsP pn-junctions by the halogen lamp annealing (HLA) technique and the behavior of deep level defects as a function of annealing temperature as revealed by DLTS (deep level transient spectroscopy).

The HLA technique was employed to activate vapor phase epitaxial (VPE) grown, Te-doped n-type wafers implanted with 150 keV, 1 x 10^{16} ions/cm^2 Zn^+ ions at 830-1000°C for 5-8 sec in an N_2 atmosphere. Activation of implanted dopants were monitored by observing photo responses at the wavelengths of 500 nm and 640 nm and the reverse current characteristics were studied as a function of annealing temperature. At 500 nm, the photo response increased while responses at 640 nm were independent of annealing temperature. The reverse current at -10 V abruptly increased at 950°C where surface damage was observed. From DLTS spectra they observed thermally-induced defects produced by HLA.

"Effects of Irradiation of Violet Rays on Halogen Lamp Annealing of As Implanted Si." K. Muto, *et al.*, Kansai University and Kyoto University.

The effects of irradiation on 50 keV As ion-implanted Si substrates by the short wavelength mercury light in addition to halogen lamp irradiated onto the unimplanted surface of the Si substrates at a constant intensity of 12 W/cm^{-2} was discussed. The irradiation time dependence of the activated sheet carrier concentration by the mercury light was similar to that by the halogen lamp of the same intensity (3 W/cm^{-2}); however, the maximum sheet carrier concentration on Si irradiated by the mercury lamp appeared at the irradiated time shorter than by the halogen lamp (5-7 sec *vs.* 30 sec) due to a large absorption in the implanted surface region.

FOCUSED ION BEAM TECHNOLOGY

Focused ion beam technology has recently generated increased attention in Japanese industries as a potential tool for maskless microfabrication of semiconductor devices. A large number of articles dealing with submicron ion beam technology are visible in the scientific and technical journals and a great deal of activities in maskless ion implantation, etching, and scanning lithography has been observed in a number of the laboratories visited. Some recent activities in the ion beam technology reported at the meeting are summarized here.

"Defects and Annealing Characteristics of Maskless Ion Implanted Si." T. Matsui, *et al.*, Osaka University and Tsukuba University.

Workers at Osaka University and Tsukuba University employed a focused Si^{2+} beam of ~0.6 μm in diameter to implant Si ions into n-type, <100> oriented Si substrates. An amorphous layer was produced at total ions of 1 x 10^{13} at the current density of 70 mA/cm^2. From ESR (electron spin resonance) studies, they found that there is no distinction in implantation effects between focused ion beam and conventional implantation techniques.

"Focused Boron Ion Beam Implantation into Silicon." M. Tamura, *et al.*, Central Research Laboratory, Hitachi, Ltd.

Hitachi, Ltd., reported on the electrical properties and the lattice disorders of Si substrates implanted with a focused $^{11}B^+$ ion beam with

diameters between 0.1 and 1 μm at a current density of about 10-50 mA/cm². A 16 keV beam was obtained from a mass separated microbeam system with a liquid boron alloy ion source and raster scanned over an area of 200 μm square at a scan speed of 2×10^{-2} -9 cm/s.

The focused ion beam (FIB) implantation resulted in lower resistivity values below 800°C than the conventional implantation and, in particular, slow scan FIB showed the electrical activation at a dose of $2\text{-}3 \times 10^{15}$ ions/cm² 14 times higher than that for the conventional implantation. Fast scan FIB implantation, on the other hand, showed nearly the same behavior as that of the conventional implantation result as a function of the ion dose. Significantly high electrical activation obtained at temperatures below 800°C for FIB implantation compared with conventional implantation was considered to be due to the increased amorphous zones created in FIB implanted layers.

MOSFET fabricated by FIB ^{+}B implantation showed the threshold voltage (V_{th}) lowering at the short channel region much less than that of MOSFET fabricated by conventional implantation.

"A High Beam Current Density Effect on Si Implantation in GaAs." Y. Bamba, *et al.*, Optoelectronic Joint Research Laboratory.

The Optoelectronic Joint Research Laboratory studied focused ion beam effect on doping behavior of GaAs using a 100 keV maskless ion implanter with a Au-Si-Be ion source (See ONR FE *Scientific Bulletin, 9* (1), 152 (1984). Lightly doped MBE grown GaAs was used for implantation with 160 keV, 0.2-μm beam-diameter Si^{++} ions at a current density of ~0.1 A/cm², which is 10^{4} times greater than the conventional, unfocused ion beam density of ~10 μm A/cm².

Raman spectroscopic studies of LO phonon peak intensity, line width at FWHM and frequency shift showed that implantation and residual damages with the focused beam were found to be less than those with the conventional beam. Moreover, postimplantation annealed, focused ion beam samples exhibited a superior electrical activity compared with the conventional, unfocused ion beam samples.

"Maskless Deposition Using Focused Ion Beam." N. Takakura, *et al.*, Osaka University.

Workers at Osaka University investigated a possibility of film deposition by focused ion beams. They employed focused 50 keV Ar^{+} or Au^{+} beams in a TMA [$Al(CH_3)_3$] atmosphere to bombard a Si wafer covered with a 700 nm SiO_2 layer at a dose of 3×10^{16}/cm². Under these conditions about 13 atoms are estimated to be deposited per an incident atom.

Auger electron spectroscopy analysis indicated a deposition of films containing Al, C, and O. Since the deposited films contain a large amount of C and O, it may not be used for low resistivity

interconnections. However, the work shows the technique can be applied to mask repair and direct mask fabrication for optical, ion, or x-ray lithography. It is estimated that the submicron sized transparent defects may be repaired with a few hundredths of second with a current density of 1 A/cm^2.

"Characteristics of Maskless Ion Beam Assisted Etching Using Focused Ion Beam." Y. Ochiai, *et al.*, Osaka University.

In this paper, the focused ion beam of 35 keV, Ga^+ was used to etch <100> oriented, n-type GaAs in various chlorine pressures at different incident angles. The ion beam assisted etching rate showed a peak at the chlorine pressure of 20 m Torr, and had a maximum at the incident beam angle of 60.

Titles of papers pertaining to maskless patterning using focused ion beam are listed below.

"Fine Pattern Definition in Gold with Atomic Intermixing Induced by a Microfocused Ion Beam." T. Kanayama, *et al.*, Electrotechnical Laboratory.

"Maskless Patterning of Cr and Al Films by Using Focused Ion Beam." K. Morizumi, *et al.*, Osaka University.

"Submicron Pattern Fabrication by Focused Ion Beams." H. Morimoto, *et al.*, LSI R&D Laboratory, Mitsubishi Electric Corporation and Osaka University.

"Maskless Microfabrication by Using Fine Focused Ion Beams." T. Shiokawa, *et al.*, The Institute of Physical and Chemical Research and Osaka University.

SEMICONDUCTOR LASERS AND CRYSTAL GROWTH TECHNOLOGY REPORT FROM A TOPICAL MEETING OF THE JAPAN SOCIETY OF APPLIED PHYSICS (JSAP)

Yoon Soo Park

INTRODUCTION

A seminar series on "Semiconductor Lasers and Crystal Growth Technology" sponsored by the Division of Electronics Materials of the Japan Society of Applied Physics (JSAP) was held on 17 January 1984 at the Kikai Shinko Kaikan in Tokyo, Japan. A meeting on specific technical areas such as this is being held frequently throughout the year in Japan. It was a half-day meeting and there were five papers. The oral presentations were all in Japanese and 20 minutes long with a 10-minute question period.

DISCUSSION

The topics presented (translated) are:

- "A visible MQW laser structure grown by MOCVD." O. Matsuda, *et al.*, Sony Corporation Research Center.

In this paper, a visible multiquantum well (MQW) laser with $Al_x Ga_{1-x} As$ well-layers grown by atmospheric MOCVD was demonstrated for several well parameters. In particular, dependence of the characteristics of the MQW lasers on well thickness (L_z) and Al content (X_z) for a composition difference $dx_z = 0.20$ in the modified MQW structure was discussed. The parameters used in the modified MQW structure shown in Figure 1 are:

barrier	L_B	= 32 and 40Å
	X_B-X_z	= $dX_z = 0.2$
well	L_z	= 32~700Å (9 wells to 1 well DH)
	X_z	= 0.13 and 0.16
active layer	L_A	= 600~700Å
clad	X_C	

The structure with a gain-guided, self-aligned narrow stripe (SAN) geometry is shown in Figure 2. The layer growth conditions used to form abrupt heteroiunctions in an atmospheric pressure vertical reactor are:

source materials	TMG, TMA, AsH_3
n-doping	H_2Se
p-doping	DMZ
group III source	1×10^{-5} atm
5% AsH_3	$2 \times X10^{-3}$ atm
carrier H_2	11 ℓ/min
growth temperature (carbon susceptor temperature)	640~780°C

The abruptness of the heterointerface as determined by Auger electron spectroscopy profiling was estimated to be about 26 A.

For L_z = 150Å, the room temperature CW threshold current (I_{th}) for a 250-μm-long MQW laser was found to be 50 mA, which is 30% less than that of a DH laser of the same geometry. As L_z is decreased, an increase in the threshold current is observed.

The CW emission spectrum shows the MQW oscillates with a single longitudinal mode at 1.05 times the threshold current for the L_Z=150Å device. The single longitudinal mode operation is maintained up to the kink power of 6 mW/facet in the L-I curve, while the DH emission spectra shows a multimode structure up to 10 mW/facet.

The pulsed lasing emission for the $L_Z = L_B = 32$Å device at $I_{th} = 250$ mA is obtained at 709 nm, which is the shortest wavelength found in the room temperature operation of the MQW type lasers.

- "$(Al_{0.3}Ga_{0.7})_{0.5}In_{0.5}P/Ga_{0.5}In_{0.5}P/(Al_{0.3}Ga_{0.7})_{0.5}In_{0.5}P$ double heterostructure visible laser diodes: MOCVD growth and room temperature pulsed operation." I. Hino, *et al.*, Optoelectronics Research Laboratories, NEC Corporation.

Growth of double heterostructure visible light laser diodes by low pressure MOCVD was presented. This is the first report that the AlGaInP compound system is grown by MOCVD.

The epitaxial layers grown on a GaAs substrate consists of five layers of:

cap	P-GaAs (Zn)	1.0 μm ($2 \times 10^{18}cm^{-3}$)
cladding	P-$(Al_{0.3}Ga_{0.7})_{0.5}In_{0.5}P$(Zn)	1.4 μm ($2 \times 10^{18}cm^{-3}$)
active	undoped-$Ga_{0.5}In_{0.5}P$	0.23 μm
cladding	n-$(Al_{0.3}Ga_{0.7})_{0.5}In_{0.5}P$(Se)	1.4 μm ($4 \times 10^{17}cm^{-3}$)
buffer	n-GaAs(Se)	0.7 μm ($8 \times 10^{17}cm^{-3}$)

Source materials and growth conditions used are:

source materials	TMAℓ, TEGa, TEIn
group V source	PH , 5% AsH_3
n-doping	10 ppm H_2Se
p-doping	DMZn or DEZn
growth temperature	640~750°C
carrier H	4~5 slm
reactor pressure	76 Torr

A laser diode fabricated from the heterostructure layers having a 22-μm-wide and 160-μm-long cavity had the threshold current density of 26 kA/cm² for room temperature pulse operation. The diode lased at a wavelength of 0.683 μm and characteristic temperature (To) measured near room temperature was found to be 72°K.

- "Growth of GaInAsP/InP structure by low pressure MOCVD and semiconductor lasing characteristics." A. Kameyama, *et al.*, Tokyo Institute of Technology.

GaInAsP/InP layers for DH lasers were grown by low pressure (76 Torr) MOCVD. Room temperature pulsed lasers with a cavity length of 290 μm lased at 1.58 μm at the threshold current density of 3.6 kA/cm² (the lowest value=3.0/kA/cm²). Growth conditions used are:

sources	TEI, TEG, PH_3, AsH_3
p-doping	DEZn or DMZn
n-doping	H_2Se_4
carrier gas	H_2

		1.3 μm	1.5 μm
growth pressure		76 Torr	76 Torr
growth temperature		640°C	649°C
mole flow rate	TEI (35°C)	8.8	8.6
($X10^{-6}$ mole/min)	TEG(-10.5°C)	2.7	2.9
	PH_3	416	166
	AsH_3	52	82

If the lattice mismatch is kept within $\Delta a/a_o = \pm 0.2\%$, photoluminescence peak intensities and widths (45-63 meV) of MOCVD and LPE grown layers were observed to be about the same.

- "GaAs-AlGaAs quantum well laser structure grown by MBE." T. Fujii and S. Hiyamizu, Fujitsu Laboratories, Ltd.

In this paper, MBE growth of GaAs-AlGaAs GRIN-SCH (graded-index waveguide separate confinement heterostructure) lasers was presented. Optimization of the layer structure of a GRIN-SCH laser was stressed and preliminary results of monolithically integrated lasers with FETs on a semi-insulating GaAs substrate were presented.

The schematic diagram of a GaAs-GaAlAs GRIN-SCH laser and a corresponding energy diagram of the layer structure are shown in Figure 3.

The layers were grown in the Varian MBE/GEN-II system with the following conditions:

substrate	(100)n-GaAs or SI GaAs
growth temperature	710°C
substrate rotation	5-18 rpm
quantrum well width	L_z = 3 to 10 μm
cladding layer composition	x = 0.4 to 0.7
barrier composition	x = 0.18
dopants	Si for n-type
	Be for p-type
growth rate	1.5 μm/hr for AlGaAs

Photoluminescence measurements at 77°K showed a formation of ideal quantum wells when compared with the PL peak energy from the quantum well and the theoretical values as a function of Lz. The variation of PL intensity was within $\pm 3\%$ and that of PL peak energy was 2 meV within a 15 mm radius area of the wafer.

A broad area Fabry-Perot laser having the cavity length of 400 μm was fabricated. The lowest threshold current (I_{th}) of 260 A/cm² was obtained for the device having Lz=6 nm and x=0.7.

Monolithic integration of ridge waveguide GRIN-SCH lasers (Lz=7.5 nm, x=0.45) with GaAs MESFETs on the SI GaAs substrate was attempted. A schematic cross section of the integrated devices is shown in Figure 4. The laser structure has a 5-μm-wide ridge waveguide and a cavity length of 300 μm. The laser driven by the FET exhibited CW operation at the I_{th}=19 mA at room temperature and a single longitudinal mode at 855 nm. The external differential quantum efficiency of 60% was obtained.

- "A visible InGaAlP laser grown by MBE." H. Asahi and Y. Kawamura, Atsugi Electrical Communication Laboratory, Nippon Telegraph and Telephone Public Corporation (NTT).

MBE growth of InGaP ~ $In_{0.49}Ga_{0.51-y}Al_yP$~InAlP was discussed. In the region of the direct transition (y=0 - 0.33), the energy gap at the Γ point increases from 1.9 eV to 2.3 eV. Therefore, the InGaAlP system is considered to have the potential for a visible laser at the wavelength of ~0.58 μ. Because of the large distribution coefficient of Al in the In based solution, LPE growth of InGaAlP crystal was unsuccessful in the past. However, recently for the first time, the authors have grown InGaAlP layers on GaAs substrated by MBE, and obtained the room temperature pulsed operation of: $In_{0.49}Ga_{0.31}Al_{0.20}P/In_{0.49}Ga_{0.51-y}Al_yP/In_{0.49}Ga_{0.31}Al_{0.20}P$(y=0.00-0.08) double heterostructure (DH) laser diodes in the wavelength range of 0.66-0.68 μm.

The layers consisting of:

Be-doped $In_{0.49}Ga_{0.31}Al_{0.20}P$ (1.6 μm),
InGaAlP (AlP=0.0, 0.03, 0.08) (0.2-0.3 μm),
Si-doped $In_{0.49}Ga_{0.31}Al_{0.20}P$ (16 μm),

were grown on Cr-, or Si-doped (100) GaAs substrates by the Anelva MBE-440 system. Before growth, substrates were heat treated at about 620°C under arsenic vapor pressure for five minutes. Growth temperatures were kept at 520-550°C with a growth rate of about 1 μm/hr. For n-type doping, Si is preferred to Sn, because of the surface segregation of Sn dopants.

DH diodes were fabricated with metalstripe (stripe with W≈70 μm, cavity length l≈200 μm) and, SiO_2 stripe (≈20 μm, l≈200 μm). Room temperature pulsed lasing operation has been achieved in these DH diodes. The InGaAlP (y=0.03)/InGaAlP (y=0.20) system, the lasing wavelength was at 0.66 μm at the threshold current density of 3.2-3.6 x 10^4 A/cm² at room temperature.

In order to achieve laser operations at a shorter wavelength, an attempt is being made to grow a multiquantum well laser structure. The structure consisting of three InGaP wells of 200Å, 100Å, and 50Å widths separated by four 500Å-InAlP barriers are grown initially. PL spectra at 77°K indicated a well-formed superlattice structure.

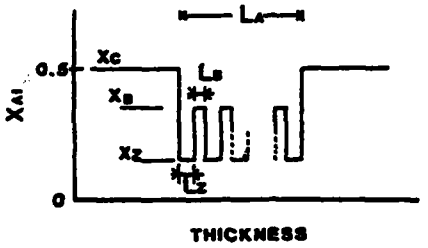

Figure 1. Modified MQW Structure.

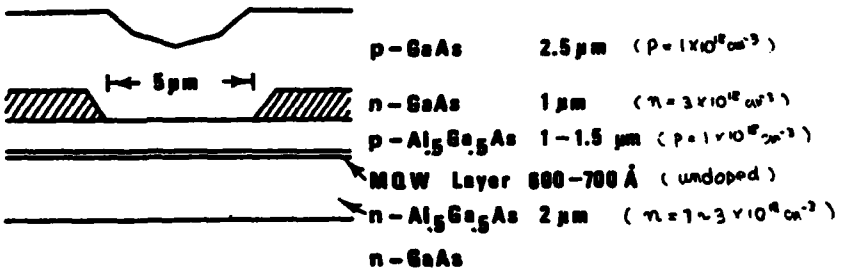

Figure 2. Gain-guided SAN (Self-aligned narrow stripe) Laser Structure.

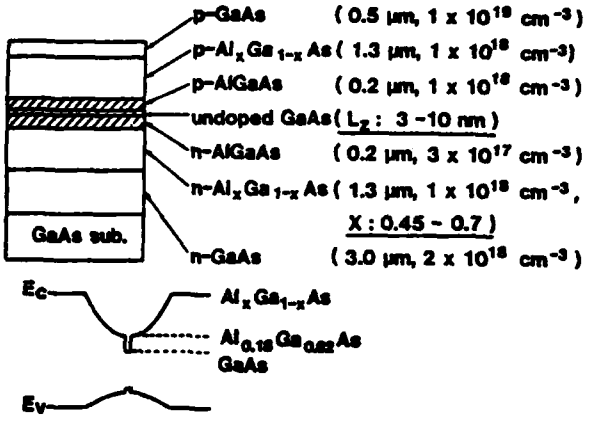

Figure 3. Structure of GaAs-AlGaAs GRIN-SCH Laser and Energy Band Diagram.

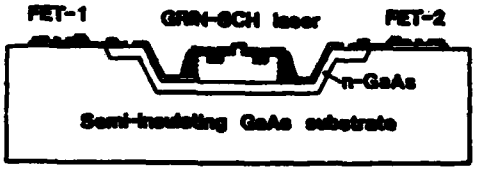

Figure 4. A Schematic Cross Section of an Integrated GRIN-SCH Laser with two GaAs MESFETs.

TABLE I

SOME CHARACTERISTICS OF $In_{0.49}Ga_{0.51-y}Al_yP/In_{0.49}Ga_{0.51-x}Al_xP/In_{0.49}Ga_{0.51-y}Al_yP$ VISIBLE LASER DIODES AT 300°K ARE LISTED.

LASER	x	y	ΔE_g (eV)	λ (μm)	J_{th} (KA/cm^2)	T_0 (K)	$\Delta\lambda/\Delta T$ (Å/K)
1	0.00	0.18	0.23	0.68	37	100	1.7
2	0.00	0.20	0.255	0.68	27	110-130	1.7
3	0.03	0.20	0.215	0.66	34	90	1.4
4	0.08	0.20	0.15	0.61 (77K)	24 (77K)		

BENCHMARKS ON THE NEW GENERATION OF SUPERCOMPUTERS[1]

Raul Mendez

INTRODUCTION

Cray Research has been the most vital and innovative force in the United States and in the world supercomputer industry since it pioneered the CRAY-1 in 1976. Cray enjoyed, until the introduction of CDC's CYBER 205 in 1981, unquestioned dominance in this very critical computer area. In the fall of 1983, a new challenge to Cray's leadership emerged with the introduction to the world market of Fujitsu's VP-200 and Hitachi's S-810 supercomputers. The introduction of the new machines coincided with that of the two-CPU CRAY-XMP. Shortly after the introduction of the Japanese supercomputers, the author travelled to Japan and had the opportunity to run the same benchmarks on the new machines as well as, upon returning to the U.S., on the XMP at NASA Ames Research Center in California. The results of these tests give the upper hand to the VP-200 over the presently available XMP on vector performance. It would be premature to conclude, on the basis of our results on this sample of five applicaton codes, that the Fujitsu machine is superior to the XMP. In fact, as long as the VP-200 runs on individual programs at a megaflop rate which is no more than twice that of the XMP, the total throughput of the Fujitsu machine could still be inferior to that of the XMP because of the two-CPU feature of the CRAY computer. Furthermore, it is unknown as of this writing how the performance of the VP-200 is affected by multitasking and I/O. Our results,

- demonstrate the importance of the software component of a supercomputer, particularly the importance of compilers as well as

- stress the need for more comprehensive testing of the new supercomputers.

In this article we shall give a partial summary of our benchmark results on the VP-200 and XMP as well as attempt to compare relevant features of the hardware and software of these machines. Although the same benchmarks have been run on Hitachi's S-810 as well as on CDC's four-pipe CYBER-205 machines, program tuning on both machines is not complete as of this writing. (It should be mentioned, however, that preliminary results in our untuned programs indicate that the S-810/20 scalar performance is inferior to that of the VP-200.) Discussion of these results will be postponed to later work.

BENCHMARK DESCRIPTION

There has long been a need to compare computers. Two of the simplest and widest used measures are floating point multiplication speed and word storage capacity. At best these two measure the hardware aspects of the machine. Furthermore, in these days of complex systems, it is the combined hardware and software that matters to the user.

To measure the whole system as a system, we have turned to running typical large problems which presumably measure the combination of parts which we are neither able to specify nor to calculate. The major weakness of this approach is that we do not know how to choose a "typical" problem in any unbiased way, and are forced to pick, arbitrarily, some reasonable problem, or problems, run them, and then use their time of solution as a measure of the overall performance of the complex system. It should be realized that while we have made a serious effort to measure performance, we know that the results are not definite, and that other problems might give different results.

Five programs contributed by fellow researchers in the area of computational fluid dynamics were used as benchmarks. The goal of this initial testing was to measure the CPU performance of the VP-200 and XMP. Special emphasis was placed on measuring the compilers vectorizing power as well as the machine's execution speed.

No effort was made to measure I/O performance. Two of the five programs, BARO and VORTEX, were run unmodified on the two machines while the other three, EULER, 2DMHD, SHEAR were modified to optimize their performance on each machine by the insertion at identical addresses of appropiate compilers directives. From these last three codes, two, MHD2D and SHEAR3, spent a significant portion of the work on Fast Fourier Transform (FFT) subroutines. In an effort to use the same yardstick to measure the two macines, we have not changed the FFT routine on either of these codes when going from one machine to the other. Thus, the performance of the 2DMHD and SHEAR programs on these machines may not yet be optimal.

A major limitation of our XMP results is that they have been obtained, in batch mode, using version 1.11 of the CRAY Fortran compiler (CFT), at NASA Ames Research Center. This software permits utilization of only one of the two available CPU's in the XMP. Software (version 1.13 of the CFT compiler) to utilize concurrently in one computer code the two CPU's in the XMP will not be available for some time (estimated by different sources to be between a few months and a year). We must therefore rely on preliminary results run under version 1.13 of the CFT compiler at CRAY Research in Chippewa Falls, Wisconsin, to put our benchmarks in perspective. The Chippewa Falls results suggests that a factor of between 1 and 1.89 is gained in performance when two CPU'S are used. It should, however, be apparent that the design of software that allows optimal utilization of both processors by a computer program has been a major challenge in the design of two-processor systems.

HARDWARE COMPARISON

The XMP and the VP-200s have central memories maximal capacity of 32M bytes and 256M bytes respectively (the vector registers of these machines have capacities of 4k bytes and 64k bytes respectively). While the VP-200 has a superior capacity in central memory, mention should be made of the XMP's SSD (solid state device, 128M byte extended memory), a feature not available in the VP-200 which is used for temporary storage. The architecture of the two machines is similar with each machine including both a scalar and a vector unit. However, the scalar unit of the VP-200 can do floating point arithmetic in parallel with its vector processor, while the XMP must share its floating point functional units between its scalar and vector units. The scalar unit of the VP-200 runs at 15 nsec per cycle while its vector unit runs at 7.5 nsec. Both units run at 9.5 nsec per cycle in the XMP. A critical feature of the VP-200 is its 128-bit vector register-to-vector functional unit data pathways, with a capacity twice that of the XMP. For some codes this feature may result in a throughput for the VP-200 which is twice that of the XMP. This observation may be documented by the vector performance of program BARO; although the two compilers vectorized nearly the same DO loops, the ratio from the CPU time of the XMP to that of the VP-200 is 1.98. How this apparent advantage compares against the two-CPU feature of the XMP cannot as of yet be ascertained.

It is interesting to note that despite their different scalar machine cycles both machines appear to have comparable scalar capabilities as it is borne out by our benchmark record (Table II). This can be understood by comparing the two machines' floating point add and multiply CPU times. We see in Table I that each operation requires less cycles in the VP-200 than in the XMP and that the CPU time for these two operations is nearly the same in both machines.

SOFTWARE COMPARISON

It has been believed for some time now that a software gap may exist between the U.S. computer industry and its Japanese counterpart. Our benchmark record appears to indicate that, in what concerns supercomputer software, the software gap may be closing. Comparison between the compiler performance of these two machines in our benchmarks reveals (Table III) that the VP-200 compiler vectorized significantly more DO loops that its XMP counterpart. This record may be the result of features in the VP-200 compiler which are unmatched in the CFT compiler as of yet. For instance, this compiler can decide which of three sets of hardware vector instructions to pick in order to optimally vectorize a DO loop which includes an IF statement (this particular feature requires that the user input the truth ratio of the IF statement). The XMP will vectorize a DO loop with an IF, only through nontrivial code modification which may include the use of CFT functions (however, future versions of the CFT compiler will be able to vectorize loops with IF statements). This particular feature accounts for the significantly better performance of the VP-200 on the code VORTEX (to be discussed below). The record on program EULER indicates that the VP-200 compiler can vectorize, with the help of compiler directives inserted in the code, some DO loops with data dependence that the CFT compiler cannot handle via compiler directives. Another interesting feature of the Fujitsu compiler, not available on the CFT compiler yet, is worth mentioning. The VP compiler has the ability, through a compiler directive, to replace a call to a subprogram by the subprogram itself (in-line subprogram integration).

BENCHMARKS AND RESULTS

We shall now briefly describe the results of our benchmarks. We emphasize again that the results described below were obtained by running on both machines in batch (nondedicated) environments, and that no effort was made to measure I/O performance but that instead we concentrated our efforts on measuring the CPU and vectorizing performance of the two systems.

We will describe first the two codes, BARO and VORTEX, that were run unmodified in the two machines. Identical copies of these codes were run in both machines and because no optimizing compiler directives were used their performance as of yet may not be optimal.

The code BARO, written by Tom Rosmond (U.S. Naval Environmental Prediction Research Facility), was specially designed to vectorize well on a vector processor. This code has been used by him to benchmark the CYBER-205. It is a finite difference approximation to a two-dimensional shallow water atmospheric model. Time differencing is leapfrog. The domain of interest is a periodic channel and in our tests a resolution of 300 points and 150 points was used. The code consists of 959 FORTRAN lines and six subroutines. Out of a total of 88 DO loops, there were 58 loops that were vectorized by the two machines and there were six loops vectorized by the VP-200 which were not vectorized by the XMP. Flow trace routines used reveals that these loops used less than 1% of the total CPU time. Thus, it appears that the CPU ratio of 1.98 (Table IIa), in favor of the VP-200 may result from a higher throughput as mentioned above. This may be a consequence of the 128-bit data pathways connecting vector registers and pipeline functional units in the VP-200. As mentioned above, this advantage may be balanced by the two CPU's in the XMP. It is unclear as of this writing how well the 1.13 version of the CFT compiler can utilize both CPU's on one program. This question will be investigated in later work.

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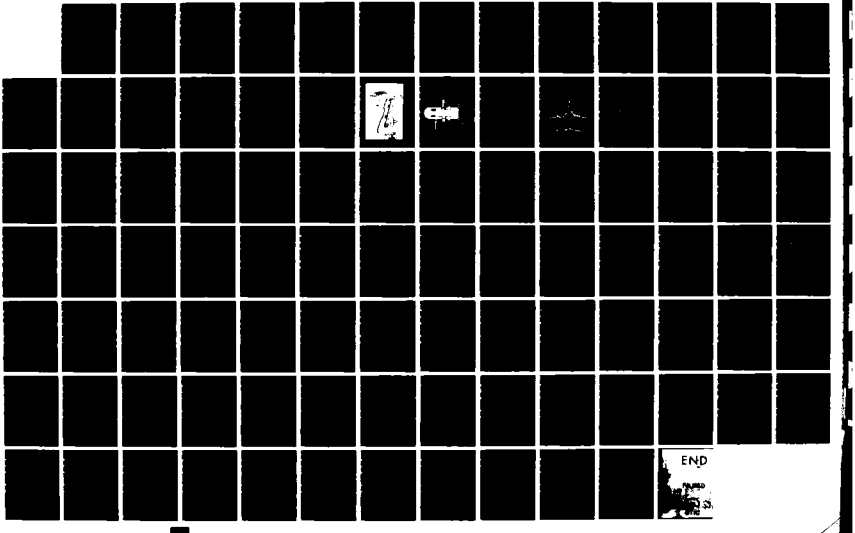

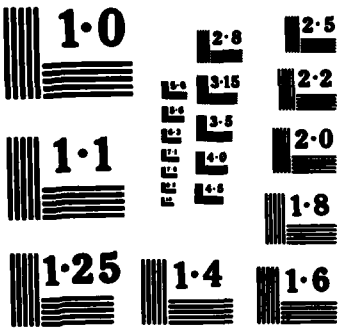
1·0
1·1
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The XMP outperformed the VP-200, in this code, in scalar performance with a CPU ratio of 1.47.

The code VORTEX was written by Donna Burych (U.S. Naval Postgraduate School) and the author. This code computes the dynamics of a tense vortex sheet (a leaflet) in an inviscid fluid. The vortex sheet is represented by means of a collection of discrete modified vortices whose strengths vary according to a conservation law. The motion of the sheet is found by the superposition of the fields induced by each vortex; because vortex shedding is assumed at the end of the sheet, the amount of work increases from iteration to iteration. A collection of 21 markers, the bound vortices locations, were used to track the motion of the leaflet while the number of vortices needed to describe the sheet in the wake coincided with the timestep. This code was run for 500 iterations (there were 521 total vortices in the last timestep). The code VORTEX consists of 617 FORTRAN statements and 21 subroutines. At each iteration n, most of the work, o (n**2), is done by a subroutine, named U, which computes the vortices' velocities by superposition (a flow trace utility run on the XMP shows that 85% of the total CPU time was used by this subroutine). This computation relies on a cutoff to smooth out the velocity profile when vortices are close to each other. This in turn results in an IF statement in the two DO loops (DO 2 and DO 3) in subroutine U. Out of a total of 33 DO loops, the XMP vectorized 11 (which in the XMP amounted to less than 0.1% of the total time) while the VP-200 vectorized 19 including DO 2 and DO 3 in subroutine U (these two loops were not vectorized by the XMP). The XMP's vector performance, on this code, coincided with its scalar performance (Tables IIa, IIb). In fact, because of the overhead needed to start vectorization, the vector performance was slightly worse. The ratio in CPU vector performance between the two machines is 6.6 in favor of the VP-200. This result highlights the importance of the VP-200's hardware vector instructions for vectorizing control DO loops as well as the sophistication of its compiler (capable of deciding which of a set of three hardware instructions is optimal). It should be emphasized that vectorization of DO Loops 2 and 3 is possible on the XMP through code modification, through the use of special library functions, but such modification would defeat our attempt to use the same yardstick to measure the two machines. Since program VORTEX was originally run on an IBM-3033, a scalar machine (500 steps run on this machine in nearly 30 minutes, using 32-bit arithmetic), it is disputable whether this code is an appropiate choice to benchmark a vector processor. Nevertheless, in addition to bringing out the significance the features describe above, VORTEX illustrates another important point. It underscores the appeal that the Fujitsu machine may offer to a very important market: the high-end sector of the IBM mainframe market (discussed in the first half of this article). The VP-200 is IBM-compatible (VORTEX ran the first time, unmodified) and it executed this program nearly 51 times faster than the IBM-3033 (the vector processor strategy of IBM as well as whether IBM will permit compatibility to continue in the future remains unknown as of this writing).

The scalar CPU-performance of the VP-200, in this benchmark, was superior to that of the XMP by a factor of 1.08.

The code EULER was written by Leonidas Sakell (Naval Research Laboratory) and has been used by him to benchmark the Texas Instrument's Advanced Scientific Computer (TIASC). This code computes one-dimensional, compressible, inviscid flows with shock waves via pseudospectral techniques by solving the full EULER's equations of motion. The pseudospectral approximation relies on Chebyshev collocation and on Chebyshev expansions to obtain spatial derivatives and on finite difference algorithms to obtain time derivatives. The code includes 1390 FORTRAN statements and 21 subroutines. The code was run with a resolution of 128 collocation points and the same number of

Chebyshev modes for a total of 1000 iterations. Out of a total of 73 DO loops, 51 were vectorized by the VP-200 while 24 were vectorized by the XMP. In the XMP, 8% of the total CPU time was used by subroutine CHEB. This routine computes all Chebyshev coefficients at each timestep as well as all spatial derivative coefficients (this subroutine is called six times per timestep). In this routine, the VP-200 vectorized all six DO loops (one of these, DO 50, with the help of a compiler directive which had no effect on the XMP) while the CRAY machine vectorized four of them. Subroutine CHEB calls an FFT routine once. This routine is used in the XMP about 45% of the total CPU time. In this FFT, out of a total of eight DO loops, four are vectorized by the VP-200 while two are vectorized by the XMP. An attempt to optimize the performance of EULER in both machines was made by inserting the same three compiler directives at identical locations on the programs. Two of these were used to prevent attempts by the compiler to vectorize two unvectorizable loops. The third directive was placed preceding a DO with a data dependence which is not a recurrence. The VP-200 was able to vectorize this DO loop while the XMP was not.

The vector performance ratio corresponding to this code was 1.58 in favor of the VP-200, while the scalar performance ratio was 1.45 also in favor of the VP-200.

The remaining two programs, 2DMHD and SHEAR, have been written by Steve Orszag (Massashusets Institute of Technology). As mentioned above, these two programs' CPU performance depends critically on the same FFT routine. To maintain identical conditions in the experiment, we have measured the performance of both machines with the present FFT. In later work, we shall study the effect of replacing Orszag's FFT by each machine's library FFT.

SHEAR and MHD2D have been tuned on both the XMP and on the VP-200. Because our tuning in the XMP may not be optimal as of yet, we shall postpone discussion of the vector performance results on these two programs to a later article. It should be mentioned, however, that our preliminary untuned vector results on these two codes gives the upper hand to the VP-200 over the XMP. The scalar performance on these two codes was mixed. The VP-200 had the upper hand in SHEAR, with a CPU ratio of 1.15 and it was slower at a ratio of .90 than that of the XMP in program 2DMHD.

CONCLUSION

The results of our measuring programs give a clear edge to the VP-200 over the presently available (only one of the two CPU's can be utilized) XMP in vector performance; the record in scalar performance is about even. However, it is not clear at all from these benchmarks that the total throughput of the VP-200 would be superior to that of the XMP. Additionally, as has been emphasized above, it is not clear yet that a different set of benchmark problems would yield the same conclusions. The need for further testing is therefore essential, and we propose to continue our benchmarking efforts in later work.

TABLE I

	VP 200		XMP	
	CPU Time (ns)	# of clocks (1 clock=15 ns)	CPU Time (ns)	# of clocks (1 clock=9.5ns)
Floating Point Addition	45	3	57	6
Floating Point Multiplication	60	4	67	7
Integer Add	30 (32 bits)	2	28.5	3

TABLE IIa

SCALAR

Program (500 Steps)	VP 200 (sec)	XMP (sec)	XMP/VP-200
VORTEX3 (Niter=1000)	217.2	233.6	1.08
EULER	6.3	9.0	1.43
2DMHD	43.4	39.2	0.90
SHEAR	164	190	1.16
BARO	1,107.8	190	0.68

TABLE IIb

VECTOR

Program	VP 200 (sec)	XMP (sec)	XMP/VP 200
VORTEX (500 Steps)	35.4	233.9	6.60
EULER (Niter=1000)	4.8	7.7	1.60
2DMHD	2.6	NA	NA
SHEAR	83.6	NA	NA
BARO	41.1	81.5	1.98

TABLE III

COMPARISON OF COMPILER VECTORIZATION OF DO LOOPS

PROGRAM NAME	TOTAL NO. OF LOOPS	LOOPS VECTORIZED BY VP-200	LOOPS VECTORIZED BY XMP
BARO	88	64	58
VORTEX	33	19	11
EULER	73	51	42

A JAPANESE DECISION AIDING SYSTEM

Nicholas A. Bond, Jr.

INTRODUCTION

Some of the most useful decision aids are quite simple in concept and in application; the user can see just what is involved. As one example, consider the "life tables" and other statistical tabulations which are the basis of the insurance industry. An actuary who wants to estimate the risk of accepting a new insurance applicant would do well to consult past claim records of applicants with similar demographic characteristics, and he also should look at the past accident record of the applicant. (In California, such information in official state records is available to the public for a small fee.) Though the details of actuarial science can be complicated indeed, there is no basic mystery in the assembly and the use of the data bank compilation. Another valuable but obvious decision aid is the radar plan-position indicator, which displays all the aircraft flying in a given area; by means of such a display and a set of priority and communication rules, many airplanes can be safely controlled from a single tower or center, and so commerical air traffic is feasible in densely traveled areas. For the in-flight pilot, navigator, or engineer there will be several instruments, tables, scales, and analog computers to assist in the planning and execution of a flight plan. In general there are many devices for encapsulating wisdom into some gadget or booklet. One of the persistently best-selling American books of the past ten years is the "idiot's guide" to Volkswagen maintenance, which can certainly be a great help to an inexperienced mechanic. All such items could be called decision aids.

The term "decision-aiding system," however, has come to mean a relatively complex arrangement of input devices, computers, software, and displays. A typical system can accept multiple sources of data from sensors or human users; it processes the information in ways that may be difficult or impossible for a human decision maker (DM) to accomplish, and it can produce outputs that may be quite complex and nonintuitive. Such systems are avowedly rational, in the sense that the logic of data flow and processing within them can be explicated and that this logic will appear reasonable to a competent analyst. But such systems may not be very transparent; that is, a typical user may have to trust the aiding system and may not understand all the details of just what it is doing at any given time. Furthermore, decision aids are often put together so that they cannot easily be modified by the user. In the military application domain, computerized decision aids have been evaluated in such areas as strike planning, the shipboard maintenance of complicated hardware, and in antisubmarine warfare (ASW) target analysis. Increasing numbers of successful utilizations have been reported, though many disappointments have also been experienced. As examples of the latter, it appears that remote computer-aided medical diagnosis is still quite rare, and that despite many massive efforts and elaborate setups, trouble-shooting aids and automatic test equipment have not been as successful as had been hoped. Certainly the need for effective human diagnosticians and trouble-shooters has not yet been alleviated.

Some decision-aid designs are driven by the specific requirements of a certain area, such as undersea warfare or the operation of a lubricant blending plant. In ASW, the unique processing needed for spectral analysis of noisy sonar signals may favor very specialized systems which are not easily used outside the narrow ASW domain. There has also been, however, a widespread recognition that many decision problems can be formulated within a general decision-analysis formulation, and so packages have been produced using classical decision theory, with local scenery features such as the names of

variables and parameter values being inserted by the user. Perhaps the most famous of these general aiding packages is the MANECON set of programs from Harvard Business School. Reflecting the textbooks by theorists like Schlaifer and Raiffa (1968), MANECON programs have been used by many thousands of students in American colleges (though it is surprisingly difficult to find real world applications!). Such programs elicit information about subjective probabilities and payoffs in a systematic way, and they keep track of all the numbers; under favorable conditions they can calculate the utilities of various alternatives and thus facilitate choice by a human decision maker (DM). The original MANECON univariate decision aid series was written in FORTRAN, and there have been revisions which extended the analysis to several criteria or objectives. In the early 1970s, Geoffrion and Dyer (1972) at the University of California, Los Angeles (UCLA) described their multiobjective interactive aiding system. Several goals or objectives were insertable, and by appropriate commands a user of the UCLA system could play with alternative probabilities, tradeoffs, and utility values in real time: the flexible adjustments and the instant feedback could give a real feeling of man-computer interaction. Over the years, work has continued on various aspects of the aiding problem. Mathematical analysts have been able to decompose complex problems in ways that permit practical solutions to be computed; some nonlinear problem conditions, for instance, can be approximated so that efficient linear optimization methods can be run. The psychological research community has pursued the study of judgmental values, biases, and elicitations. At the hardware end, the terminals themselves, the central computer processing, and the memory capabilities have all been radically improved. The array of commercial software available is now very impressive; in fact, there are so many options that it is a real decision problem to choose among the aiding packages on the commercial market.

At Kobe University in Japan, Masatoshi Sakawa has a medium-size aiding setup which is quite general, and which includes many of the recent advances. Sakawa's system has undergone several modifications, and his work has been sponsored by organizations such as the International Institute of Applied Systems Analysis (IASA) at Laxenburg, Austria, by IBM Japan, and by various Japanese government agencies. The Kobe system is now up and running in several versions; it clearly solves some textbook-type multiobjective decision problems with realistic inputs, and the computer installation required to drive it is rather modest by 1984 standards. Thus, Sakawa's system not only gives us a glimpse of the Japanese state-of-the-art in general decision aiding, but it also points up some of the problems which still must be attacked before such systems can expect wide application.

- Approach

Sakawa started with a definite orientation toward the present state-of-the-art. He knew that a multiobjective capability was essential for dealing with real problems, that human judgment inputs would be required for much of the problem information, and that the criterion or value functions might well be of several different shapes. He also wanted to utilize any well-known tricks for reducing the computational load, so that real time interactions would be feasible with medium size minicomputers. Among the more technical assumptions was that a DM could make consistent choices concerning multiobjective prospects even though the form of DM's utility function might be known only implicitly. Another assumption was that subjective marginal rates for substitution (MRS) could be reliably elicited, and could be used to estimate the direction in which the overall utility function increases most rapidly. (To get an MRS, the DM has to say how much of one objective, say f_i, he is willing to give up to gain an additional unit of another objective, say f_j. The MRS is then the negative slope of the indifference curve near a locus of indifferent points derived from such judgments.)

Sakawa's program thus incorporates many of the recent features and techniques of interactive decision analysis. The program has internal means for checking the consistency of the input judgments, and in at least some versions the inconsistencies are reflected back to the DM until the irrational discrepancies are resolved to a preset tolerance. There are ingenious procedures, some originated by Sakawa himself, for determining optimal step size in setting up the trade-off comparisons across criteria. The whole system operates only on the set of Pareto-optimal points in the utility space: that is, the only solutions considered are those wherein an improvement in one criterion cannot be achieved without reducing a score or rating or another objective. Thus the system does not waste time on strategies that are clearly dominated.

To illustrate the kinds of problems that can be addressed by his system, Sakawa sets forth a Japanese resource allocation problem as a benchmark (decision analysts will be reminded of the famous Keeney-Raiffa (1976) airport location example). The problem is a real one, and concerns industrial development in the Osaka area. Osaka itself has over two million people; it is the center of a large manufacturing area which extends for many miles. (To the Western visitor, Osaka might resemble Chicago or Houston in its strong business orientation and its pace of activity.) Population growth and industrial development have been rapid and are generally well accepted as desirable, but there are strong pressures on the water supply system which depends on the Yodo River and its tributaries. Air pollution in Osaka is also widely recognized as a worsening problem, with SO_2 levels being judged as particularly critical. To solve or even to face the decisions involved for medium-term industrial planning, several constraints have to be taken into the calculation. The area is already densely populated, perhaps overpopulated, and there is only so much land and so much water available. Similarly, capital accessibility within and across the various industries is an important limiting factor, although it can be controlled to some extent by government and banks. Because Japan is a political democracy and must be responsive to citizen reactions, there are also frictional constraints: working industries cannot simply be closed down overnight, and drastic changes in the industrial structure are accompanied by extremely high social costs. Within such constraints, the analyst's problem is to estimate optimal levels of capital and labor within the 20 or so major industries (food, textiles, chemicals, iron and steel, precision machinery, and so forth). Sakawa's system seeks to maximize total production, to minimize chemical oxygen demand, and to minimize SO_2 in the air. He sets up precise definitions of each one of these three objective functions, and also establishes definite constraint indexes.

At first glance this problem may appear to be so complex as to be insoluble; in fact, for that very reason the usual democratic solution to such complexity is to try out a few incremental changes and then to watch the response of the various interest groups in the community as the changes take hold. Some kind of democratic compromise often can be achieved in this way. But everything does not have to be determined by pressure group and media reactions. Sakawa found that, by consulting official statistical sources, it was possible to get pretty good estimates of the capital, resource, and constraint parameters; industrial unit loads of such quantities as oxygen demand and sulfur dioxide could also be discovered with reasonable accuracy. For instance, from official publications one finds that the pulp and paper industry chemical oxygen demand is extraordinarily high and that much fresh water is required per unit shipment, whereas the machinery and furniture industries are definitely low in these requirements. Table 1 shows a fragment of the values employed in the analysis. Though every number in the tabulation was soft to some extent, the estimates were often quite verifiable, and probably were as good as the numbers which are routinely used for corporate planning (Sakawa, 1983; Sakawa and Seo, 1983).

When Sakawa's optimizing program was actually run in realistic trials with inputs from exemplary human judges, one version accepted fuzzy trade-off judgments regarding minimum and maximum acceptable levels on the three criterion functions, and also processed relative fuzzy judgments across the three objectives. The solution that came out appeared reasonable enough to the casual eye. Food and printing, for example, turned out to receive an expanded capitalization and labor force under the computed optimal scheme. Indeed, the optimal solution might indeed be just about the best that could be done.

- Implementation

What can one say about Sakawa's system? He has included in it a good variety of the known tricks and techniques, the system is rather friendly; his judges are free to choose different utility functions (though they would have to recognize the shape of these functions, a difficult task itself). The various subroutines have been tied together nicely; the whole thing works. As already noted, values do emerge as outputs and these can be shown to be the best obtainable under the constraints and assumptions. These outputs might be used by planning agencies and by industrial institutions themselves. All the analysis going on, as far as the writer can see, is quite rational and defensible. But according to informal inquiry such programs are not routinely used in Japan. Maybe we can hardly expect instant implementation. The question is, why not? What are the factors which limit acceptance and utilization of these decision aids, which really do have remarkable capabilities? Informal talks with a grab sample of Japanese analysts and potential users did furnish some hints concerning the implementation of medium-scale general decision aids.

Some potential users say that a large part of the skepticism and mistrust comes from the judgmental inputs which go into the analysis. Numbers have to be assigned to probabilities and to values. A critic can always say that "such things can't be quantified," or he can point out that "...somebody else's set of judgmental values can wipe out your whole analysis; the whole thing is built on sand." A related objection is that the judgments demanded by the system are simply unnatural"...it's like asking you to balance apples and oranges." As a further criticism, the procedures may also be rejected as impractically repetitious and tedious: "... nobody would be willing to make all those comparisons; your judges would burn out pretty soon." Such remarks are often accompanied by other sage and negative observations, such as "garbage in, garbage out."

While there may be some truth in these criticisms, they really do not constitute grounds for dismissal of the aiding system concept. Researchers now know a lot about judgments of value and uncertainty. Reliability coefficients of complex probabilities and subjective values now can be computed thus providing a technical answer to the criticism that such judgments are vague and unreliable. Evaluation processes are indeed complex, but they are not that mysterious. It appears that mental algebra is often done by estimating expected gains and losses from a neutral reference point (Tversky and Kohneman, 1982). The psychology of confidence is advancing too, and there is a significant body of knowledge on the calibration of subjective probabilities. (Fischoff and MacGregor, 1982). Though decision-makers often seek, or even impose, a dominance structure on a complex domain in order to reduce the processing load, the process of establishing the structure can itself be aided (Sage, 1982). Experience with a given judgment situation may become so routinized that after many trials, the judgments become relatively effortless and intuitive (Anderson, *et al.*, 1981); a practical implication of this result is that people can manage difficult rating tasks quite well after suitable practice in doing that sort of work. The dimensionality of actual

decisions, such as those observed in airborne antisubmarine warfare or stock market trading behavior has been fairly well determined, and aiding schemes organized around the dimensions can be expected to improve performance. When recent advances like these are considered, I believe that no informed person can reasonably say that "judgment cannot be quantified," or that the data being used as inputs to aiding systems are so intrinsically unreliable that the whole setup is just a laboratory curiosity.

A second set of reasons for resistance, however, has to do with the user constituency itself; and here is one place where it does seem that there is grounds for criticism of the aiding system design community. Take the Osaka allocation problem which Sakawa uses as a demonstration and benchmark problem. It seldom happens that an end-user person or agency (such as a regional planning authority) comes to the aiding analyst with a request to produce a practical aiding system, and then stays with the project all through the development and evaluation phases. Instead, the system designer's work is often sponsored by a technical research agency, and that sponsor may most honor design characteristics such as the originality and elegance of the processing scheme. On many aiding projects, only when a system has been built, or at least outlined, do real applications enter the picture, and by then there may not be much room for drastic redesign. The result, then, is that the user constituency may not be committed or involved enough in the system to seek its application actively. The potential user may also perceive that the design people are forcing his problem into some particular matrix with which he is not comfortable. Those cases where the user constituency is involved throughout can be very successful. One class of successes comes from the large computer maintenance industry. In banks, insurance companies, and government offices, there often is a contracted major computer mainframe with a small minicomputer or two for backup. Because of the economic and time stakes, there is strong pressure to keep the large computers on the air, and a corollary demand for rapid location and restoration of equipment faults and troubles when breakdown does occur. The manufacturer often contracts to provide corrective maintenance services. A set of semiautomatic fault locator routines is the key decision aid to the field technician trouble-shooting the mainframe and disk drives, and these aids usually are quite effective. In some companies the user constituency here (the field technician) is carefully involved at every step of the aiding-system development. It may be routine practice for field technicians to be sent back to the factory when such aids are being produced. There can be two kinds of benefits from such a policy: one of these is the technical input from the field man who knows what he is going to face out in the field. Perhaps even more important is a second and more psychological factor, namely his close involvement early in the process. The involvement may produce a positive identification effect when the aid is finally delivered to the field. Often, it appears, such user involvement is critical to user enthusiasm; the shared problem solving by field and factory is probably the key factor. (The computer-aided system for body die design at Toyota motors in Japan is another success story which featured user involvement all the way. That case will be reported in the next *Bulletin.*)

For public kinds of problems, still a third kind of resistance was mentioned among Japanese designers and potential users, and it applies especially to large-scale decision aiding. Many planners have come to have a general distrust of the policy model approach to complex problems, and they are also skeptical about their past utilization. Japanese planners are apparently no better than others at being able to anticipate the future through such aids. Nobody in Japan seems to have predicted the emergence of many new products and processes, and government agencies who are supposed to plan for the future have made some spectacularly wrong projections. On a national scale in America there are also many examples; we can take the Federal energy policy as one illustration. In

1974, after the first oil crisis of the 1970s, many legislators and government analysts believed that the American public and the automobile industry were not taking the situation seriously, and that a variety of conservation schemes and standards should be mandated by government in order to correct the intellectual and motivational deficiencies. To establish the appropriate numbers, complex prediction models were run in order to estimate such things as future oil import and electricity demand, the growth of the nuclear power industry, and so forth. Some of the projections were dark indeed, with forecasts of grave industrial and personal inconvenience. The National Energy Plan prediction model, published in 1977 and used as a basis for legislation, estimated a 3% growth of petroleum use and an oil import estimate of 12 to 16 million barrels of oil per day by 1985. These projections were, fortunately, quite wrong; for instance, the present oil import level is about five million barrels a day. Many similar errors could be noted in the formulation of energy policies for housing and public buildings. Such experiences lead to a general distrust of expert modeling as a key to good decision making; indeed, the distrust may be worldwide and it will take a long time for it to be overcome.

Weick (1984) has recently explored the concept of the "small win" as an implementation variable. A small win aims at a fairly immediate, concrete, and minor improvement in some "big problem" area. By itself, the small gain does not amount to much, but it can mobilize support, can reduce excessive arousal in opponents, and can serve as success experiences for the advocates. A clever small win approach to implementation, with a decision-aiding system which is avowedly trying to do only a limited part of a problem, could be a very useful strategy for the medium-scale system designer.

Looking at the implementation aspects, then, it appears that designers and producers of aiding systems can benefit from recent psychological research on human judgment and that the stock objections to quantification of complex variables can be answered rather well. The research and design people, however, often ignore the user community until late in the design and evaluation sequence, and they apparently have no convincing approach to overcoming the "model resistance" in medium- and high-level decision makers. Perhaps far more involvement at all stages, and more joint setting of aiding system goals by users and designers will be necessary in order for clever decision aids to be used extensively. At least some members of the decision-aiding design community will have to be willing to get into the rough-and-tumble of the user world. In fact, there may be room for a new kind of decision-aiding specialist who is technically competent and who can also work well with potential users.

CONCLUDING REMARKS

Japan's technology in medium-size general aiding systems, as exemplified by Sakawa's setup at Kobe, seems to be about on a par with American and European state-of-the-art. Any one country can be leading in a given specialty domain of decision aid devices. Where America may be clearly ahead is in specialized military aiding of air strike planning, towed-array signal analysis, and certain kinds of target pattern recognition and econometrics. Japan may have the lead in certain kinds of computerized design and in production aids for high-precision manufacturing. There are probably enough general aiding systems around the world now to justify a comparative tabulation of their capabilities. In such a tabulation, among the important factors should be the extent to which a system takes into account the findings from recent psychological research in human judgment and evaluation, and the ease with which a range of user constituencies can be incorporated into the design sequence.

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TABLE I

SAMPLE OF PARAMETER VALUES FOR CHEMICAL OXYGEN DEMAND (COD), SULFUR DIOXIDE (SO_2), LAND, WATER AND CAPITAL (A, B) FUNCTIONS FOR EACH INDUSTRY

Industry	Capital		COD	SO_2	Land	Water
	A	B				
Foods	10.9	.11	.079	.008	.02	.04
Textile	8.6	.14	.031	.022	.07	.13
Furniture	9.9	.17	.001	.001	.02	.01
Machinery	7.4	.20	.001	.003	.05	.01

FOUR DAYS "ON-LINE" AT JAPAN'S PHOTON FACTORY

Earl F. Skelton

INTRODUCTION

In recent years, synchrotron radiation (SR) has developed as a very powerful and important tool for a wide variety of materials-related scientific disciplines. The diagnostic capabilities of various SR-related measurement techniques are in many ways unparalleled and SR sources are becoming increasingly more available. Presently, under the sponsorship of the U.S. Department of Energy and the National Science Foundation, hard x-ray storage rings are operating in the United States at Stanford (SPEAR) and Cornell (CHESS) Universities, respectively. The National Synchrotron Light Source at Brookhaven National Laboratory is scheduled to begin operation soon and other U.S. SR facilities are in the planning stage. The status in this area was recently reviewed in an article by Bienenstock and Winick.[1]

Keeping pace in this rapidly growing field, Japan began research with SR in 1963 with a 1.3 GeV synchrotron at the Institute for Nuclear Science, University of Tokyo; this was followed with a 400 MeV ring, SOR (synchrotron orbital radiation), also at the University of Tokyo; SOR has been in operation since 1974. A second Japanese SR facility, known as TERAS (Tsukuba electron ring for accelerating and storage) was first operated in October 1981. TERAS is run by the Electrotechnical Laboratory at Tsukuba and designed to orbit electrons at 600 MeV with a stored current of 100 mA. The newest, and as yet the most energetic of Japan's SR sources, is the Photon Factory (PF).

PHOTON FACTORY (PF)

PF was conceived by a small group of scientists in 1973; in the following four years that group expanded into a formal committee supported by 300 Japanese researchers. The success of the group is demonstrated by government support which was obtained in 1977 for the creation of PF at the Japanese National Laboratory for High Energy Physics (KEK). Construction was started in April 1978 and the first photons were produced in March 1982. The rapid growth of SR facilities in Japan has been reviewed in two earlier articles in this *Bulletin*.[2] In January, this author had the unique experience of being the first non-Japanese scientist to perform experiments at PF; some of that experience is summarized in this article.

PF is Japan's first hard x-ray ring; it has been in operation for more than a year and is designed to run in a 100% dedicated mode. Electrons are accelerated in five 80-m-long sections of TELL (Tsukuba Electrotechnical Laboratory Linac). The electron energy is increased 0.5 GeV in each section and the resulting 2.5 GeV electrons are then injected into the PF ring where they are maintained at this energy. (The ring can also be run at 3.0 GeV with appropriate reduction of the beam current.) The PF design current is 500 mA, but at present the operational limit is 150 mA. The beam lifetime is typically about 10 hours, and refills are usually scheduled when the beam current drops to 80 mA. Refills are reasonably fast (about 10 minutes) and the behavior of the emitted photon beam is very stable.

There are 28 bending magnets on the ring, 22 of which can be used as x-ray source points; at this time, only eight beamlines are operational, each supporting three or four experimental stations. The critical wavelength of the photon beam, i.e., the wavelength for which half of the power of the emitted spectrum is above, and half is below, is 2.98Å,

or equivalently 4.16 keV. Ultimately there will also be a three-pole 60 kG wiggler station on the PF ring for which the critical wavelength is expected to be 0.48Å (or 25.89 keV).

Two very impressive features at PF are quietness and space. In addition to the fact that the photon beam is very well behaved, the atmosphere "on the floor" is rather pensive. Audio announcements and signals are infrequent; it is usually difficult to tell the difference between night and day. (This is in contrast to the author's experiences at Stanford where the routine business hours are accentuated by a pronounced increase in the amount of information being broadcast on the public address system.) There is also at present an enormous amount of space on the floor at the PF. The shortest distance from the outer wall of the ring to the inner perimeter of the PF building is about 25 m. The ring itself is about 3 m high and the ceiling of the building is more than twice that height.

Each experimental hutch is designed and built around a specific experimental facility; generally they are very large. The one on the line that we were using could hold, in addition to the 500-ton press described below, at least a half-dozen scientists at the same time.

- High Pressure Research and MAX 80

As noted above, there are a variety of experimental techniques which are optimized with SR; that of greatest interest to this author is energy dispersive x-ray diffraction (EDXD), especially when applied to high pressure structural studies. Interfacing these experimental methods with SR has led to an increase in data collection efficiency of three to four orders of magnitude[3-6] and a significant advance in this field.[7]

These advances have been exclusively related to the microscopic samples used in diamond-anvil pressure cells, the principal tool of most high pressure researchers today. However, the Japanese have taken a major step forward in this field by interfacing a large volume high pressure system with SR. In 1980, plans were formulated by a team of Japanese scientists from five different institutions to develop a multianvil, large volume high pressure system for operation at PF, MAX 80 (Multianvil X-ray System, designed in 1980).[8] Those plans came into fruition in early 1983 when the first high pressure experiments were performed.[9]

The press itself (Figure 2) can develop a uniaxial load of 500 tons and with this, pressures of up to 13 GPa (~130,000 atm) can be developed. The sample chamber can also be resistively heated; the pressure, temperature, and sample volume limits of MAX 80 are summarized in Table 1.

One of the first materials to be examined in MAX 80 is carbon. In so doing, the first *in situ* structural study of the conversion of carbon from graphite into diamond was performed. Three EDXD spectra of carbon at a pressure of about 6 GPa are shown in Figure 3. In the lowest and middle spectra, at temperatures of 25° and 1200°C, respectively, the carbon is still in the graphitic form; in the top spectrum the temperature has been raised to 1450°C and partial conversion to the diamond phase is evidenced by the diamond (111) and (220) EDXD peaks. This large volume pressure facility will allow heretofore impossible studies of the kinetics of the graphite-to-diamond phase transition.

RECENT U.S./JAPANESE RESEARCH

The objectives of the collaborative work which was recently performed at PF were twofold: (1) to study the pressure/temperature phase diagram of zirconia, ZrO_2, and (2) to continue studies started this past fall at Stanford of the effects of pressure on the crystallization temperature of iron-borate ($Fe_{.83}B_{.17}$) metallic glasses.

In the case of zirconia, it is known that at a pressure of about 4 GPa or at a temperature of about 1200°C, the material will undergo a structural phase transition from its normal monoclinic phase to a tetragonal structure. Based on very recent work,[10] it appears that these two tetragonal phases may be crystallographically different. The objectives of the experiments performed on MAX 80 are to (1) verify this and, (2) if true, to determine the coordinates of the tetragonal-tetragonal phase boundary.

P,V,T-data were collected at 40 different pressure-temperature settings to 5.5 GPa and 700°C. EDXD spectra were recorded at a diffraction angle of $2\theta = 17.98°$ and up to photon energies of 34 keV. Evidence of the monoclinic-to-tetragonal transition was observed, but due largely to the strong fluorescence radiation from the Zr, the signal-to-noise ratio was poor. Careful analyses of these spectra using appropriate computer enhancement routines will be necessary before definitive conclusions can be drawn about this problem.

Work on metallic glasses was initiated in the Naval Research Laboratory (NRL) program at Stanford because of the unique type of information which can only be obtained with SR. The amorphous-to-crystalline transitions in most metallic glasses are exothermic and tend to occur with great rapidity. Therefore, these cannot be followed crystallographically when conventional radiation sources are employed; but recent studies at Stanford indicate that it may be possible to monitor the transformation kinetics in these materials.

The effect of pressure on the amorphous-to-crystalline transformation has a twofold effect: on one hand, the density of the amorphous phase is usually less than that of the crystalline phase thereby making the amorphous-to-crystalline conversion more favorable at elevated pressures. This, in turn, implies a reduction in the crystallization temperature, T_x, with increasing pressure. On the other hand, the growth rate of the crystalline phase is reduced at elevated pressures due to lower atomic mobility. This would suggest an increase in T_x with increasing pressure. It remains to be determined which of these mechanisms is dominant. An initial step in this program is to measure the pressure dependence of T_x. Information gained from this work will help to clarify our understanding of the thermal stability of amorphous metals.

Thirty pressure/temperature runs were made on $Fe_{.83}B_{.17}$ in MAX 80 to 6 GPa and 800°C. The amorphous-to-crystalline transition is very demonstrative in this case, as shown in Figure 4. The EDXD spectrum in the upper part of the figure is of the amorphous phase, and that in the lower part is of crystalline $Fe_{.83}B_{.17}$.

The recorded spectra are summarized in Figure 5; two very interesting discoveries were made: (1) the slope of the T_x-P curve (Figure 4) appears to be zero which is contradictory to the positive slope of the T_x-P curve measured resistively, and (2) there is evidence of a new high pressure crystalline phase at high temperatures. This new crystalline phase transition appears to be reversible, although the new phase cannot be retained at ambient conditions. Research on these interesting phenomena will continue both at NRL and in Japan.

ACKNOWLEDGEMENTS

Thanks are due to all my Japanese collaborators and hosts for this unique opportunity: first to Dr. Osamu Shimomura of the National Institute for Research in Inorganic Materials (NIRIM) for hosting my visit and, of equal importance, are my other Japanese research associates, Professor Syuniti Akimoto of the Institute for Solid State Physics (ISSP), University of Tokyo and Professors Akifumi Onodera and Kaichi Suito of Osaka University. Thanks are also due to Dr. Shinobu Yamaoka and other scientists from NIRIM and ISSP for help in the experiments. Finally, I am grateful to Professor Murli Manghnani of the University of Hawaii for help with some of the graphics used in this article.

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   - National Research Institute for Metals.

9. "Multianvil Type X-ray Apparatus for Synchrotron Radiation," Shimomura, O., Yamaoka, S., Yagi, T., Watatsuki, M., Tsuji, K., Fukunaga, O., Kawamura, H., Aoki, K., and Akimoto, S., in "High Pressure Science and Technology," *Proceedings of the Materials Science Society, 22,* edited by C.G. Homan, R.K. MacCrone, and E. Whalley. Elsevier Science Publishing Company, New York, 1984.

10. "High Pressure Polymorphs of ZrO_2," Ming, L.C. and Manghnani, M.H. in *Proceedings of the International Symposium on High Pressure Physics Under Pressure,* edited by T. Yagi, Institute for Solid State Physics, University of Tokyo, 1984.

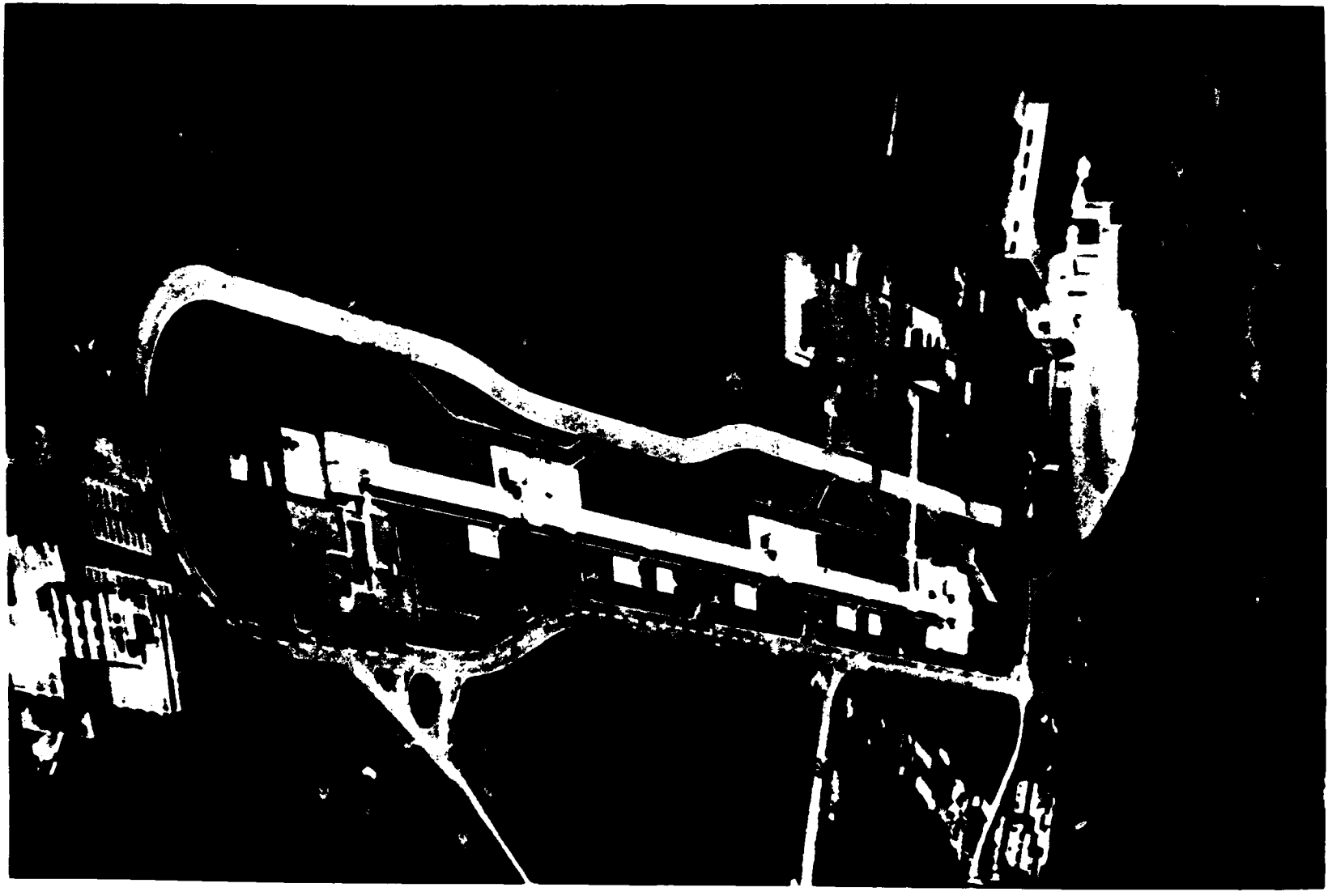

Figure 1. Aerial view of the 2.5 GeV linac, TELL (center) and the Photon Factory (upper left) at KEK, Tsukuba.

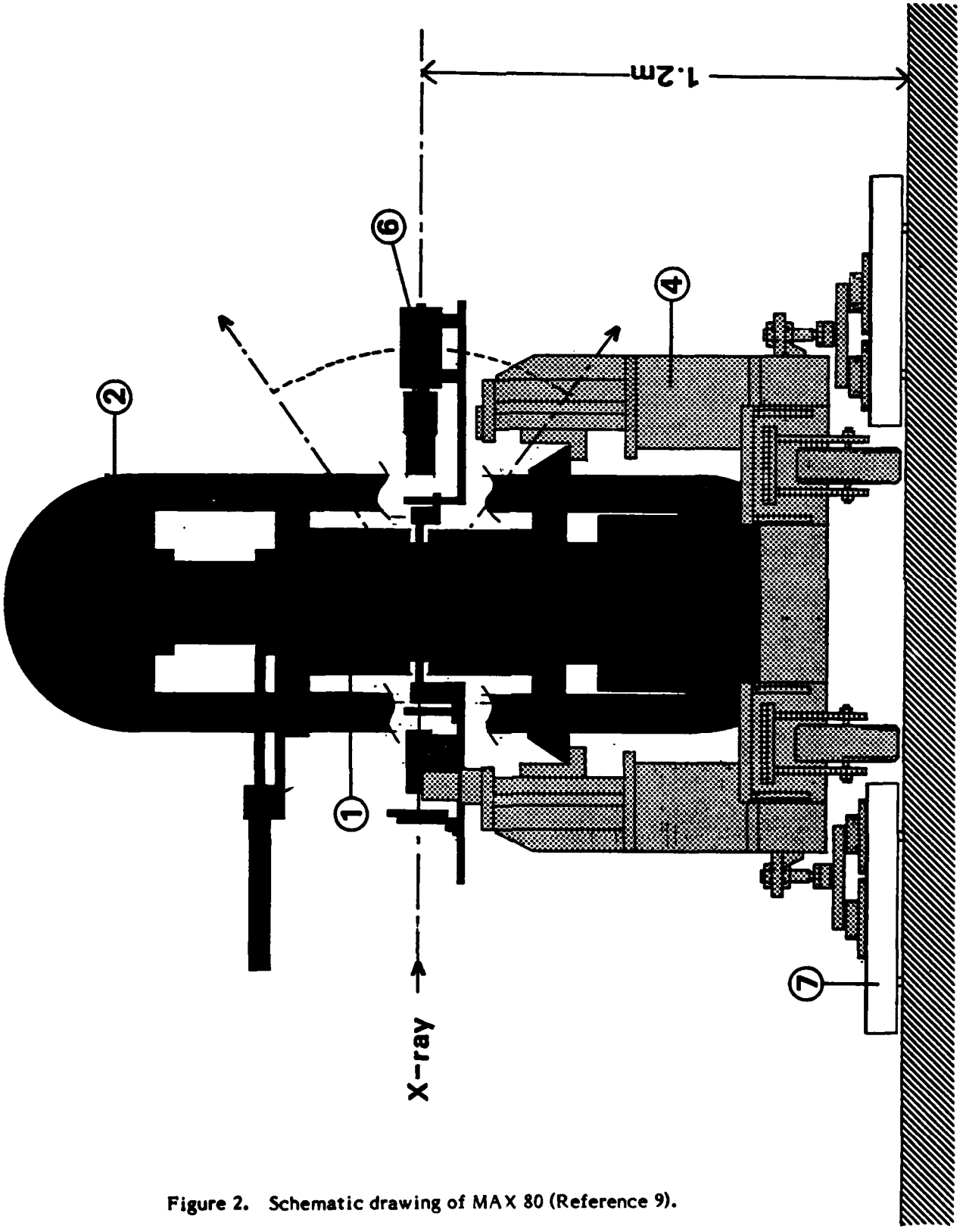

Figure 2. Schematic drawing of MAX 80 (Reference 9).

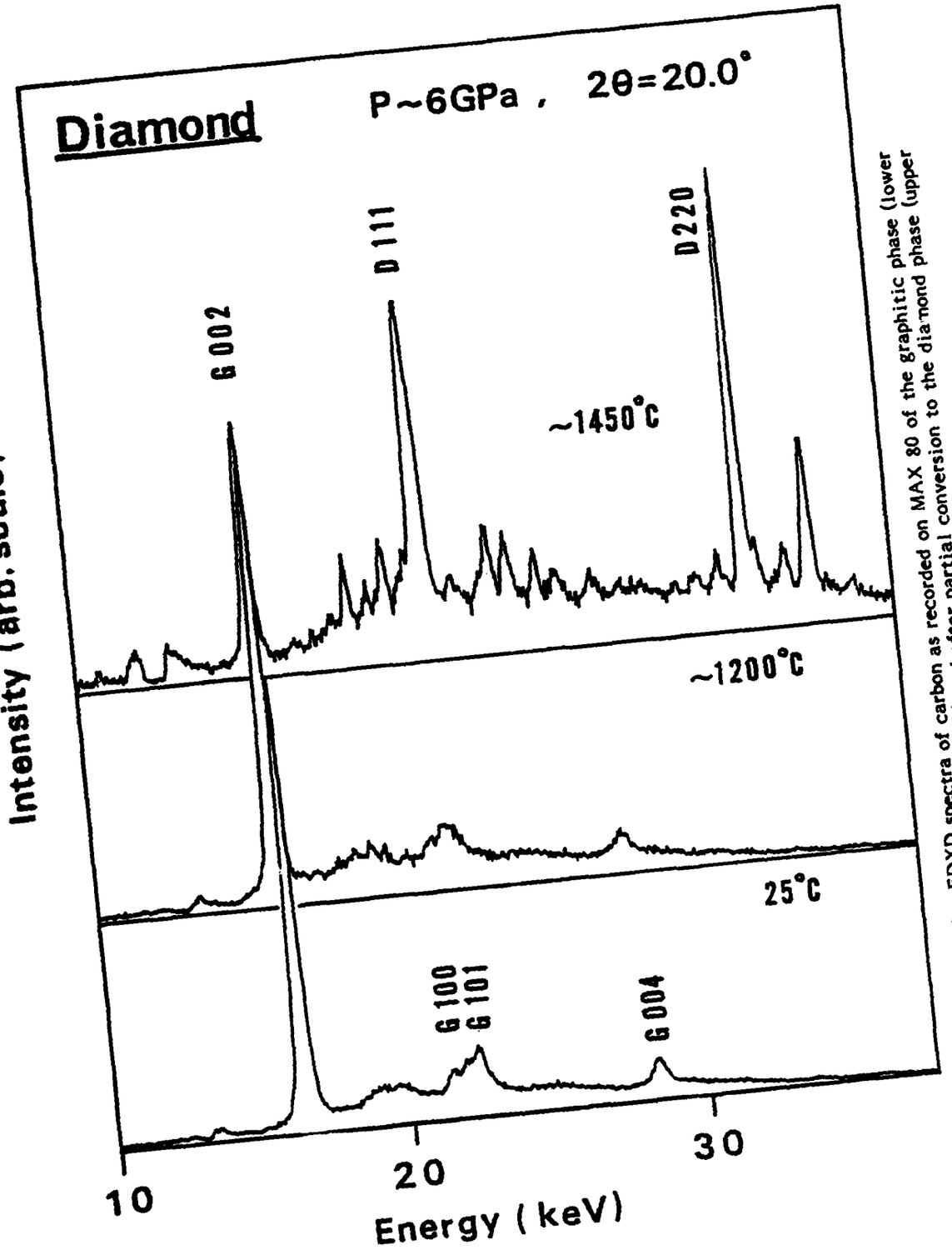

Figure 3. EDXD spectra of carbon as recorded on MAX 80 of the graphitic phase (lower and middle spectra) and after partial conversion to the diamond phase (upper spectrum) (Reference 9).

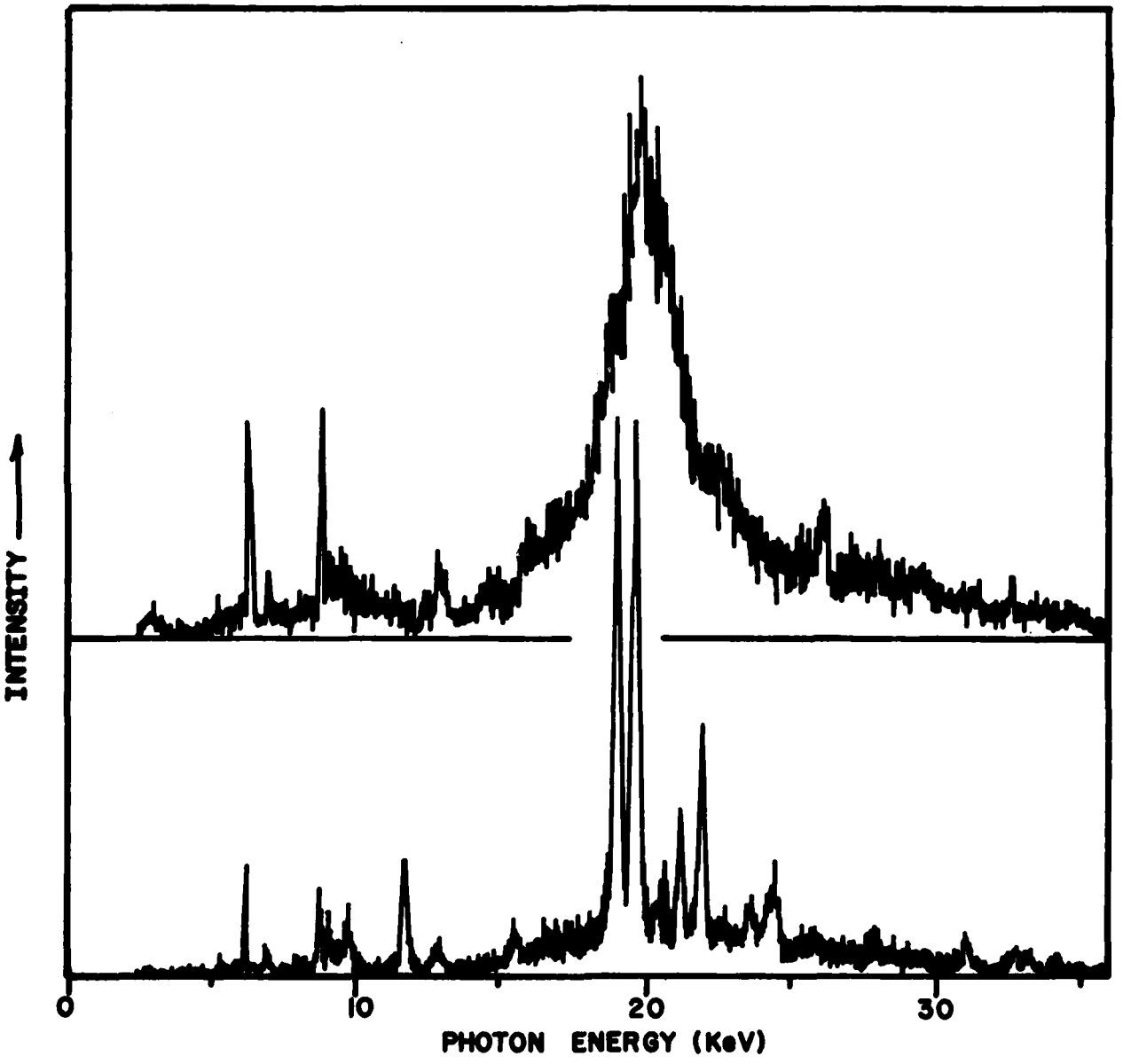

Figure 4. EDXD spectra of $Fe_{.83}B_{.17}$ as recorded on MAX 80 of the amorphous upper spectrum) and crystalline (lower spectrum) phases.

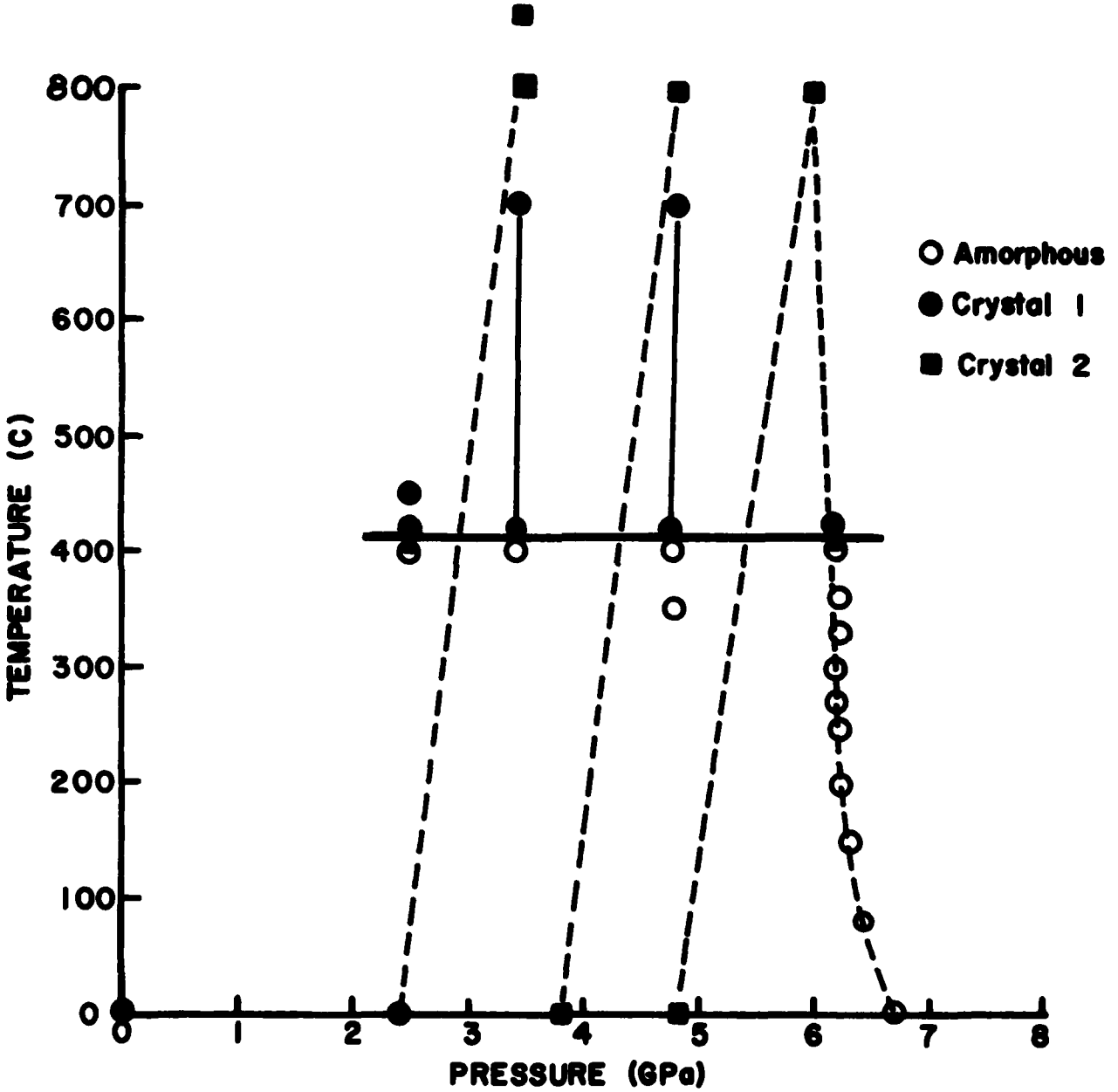

Figure 5. Summary of the EDXD spectra recorded for $Fe_{.83}B_{.17}$; the horizontal solid line represents the measured pressure dependence of the crystallization temperature, T_x; the dashed lines represent the data measurement sequence.

TABLE I

OPERATING LIMITS OF MAX-80

cube cell edge length (mm)	3	4	6
maximum pressure (GPa)	13	10	8
maximum temperature (°C)	600	1000	1700

INTERNATIONAL CONFERENCE ON LASERS, '83

James E. Butler

The International Conference on Lasers, '83, was held in Guangzhou (Canton), People's Republic of China, from 6-9 September 1983. Two of the main accomplishments of this meeting were to provide interactions between the foreign scientific community and Chinese researchers who can only infrequently travel abroad, and to provide a forum for the recent, diverse accomplishments of the Chinese laser physics, chemistry, and optics communities. The conference was organized into four parallel sessions plus poster papers, with approximately 125 foreign and 270 Chinese participants. About 40% of the 230 contributed and invited papers were presented by the foreign guests while nearly all of the 80 poster papers were given by the Chinese.

TECHNICAL SESSIONS

The thirty-two technical sessions were divided into nine general catagories. The areas of laser biology and medicine were not explicitly included in the call for papers.

- Eight sessions were devoted to "Laser Devices" which included high power CO, CO_2, excimer and glass laser systems, new solid state and excimer laser media, picosecond, dye, diode, and chemical lasers.

- The six "Laser Applications" sessions covered holography and its applications, materials test and analysis, surface preparation, chemical synthesis, and medicine.

- "Nonlinear Optics" presented four sessions of discussions of four-wave mixing, CARS, SHG, THG, optical bistability, multiphoton spectroscopy and ionization, and birefrigence.

Four sessions were devoted to the diverse "Materials and Components" of lasers, e.g., lasing, electrooptic and nonlinear crystals, lasing glasses, and dyes.

- The "Laser Chemistry" sessions, three in number, covered IR-laser-induced chemical processes, multiphoton dissociation, and laser studies of chemical kinetics and biomolecular reaction dynamics.

- Three session of "Laser Spectroscopy" discussed IR diode laser spectroscopy and transient detection, the application of multiphoton techniques to excited states and ions, LIF of gas phase diatomic molecules, and spectral properties of tunable lasers.

- The two "Laser Plasma" sessions covered laser-plasma interactions, laser fusion research, and free electron laser design.

- Various theoretical aspects and models applying to laser media and spectroscopies were presented in the session on "Laser Theory."

- The session on "Engineering and Technology" discussed optical resonator designs, phase conjugate arrays, and magnetooptic single crystal films.

My participation was primarily in the Laser Spectroscopy and Laser Chemistry sessions where I presented papers on the "Infrared diode laser spectrosocopy of the transient molecules PO and BrO," and the "Laser probing of elementary reaction dynamics: the O ($^1D_2$) + H_2, HD, D_2 reactions." Two excellent Chinese offerings in the Laser Spectroscopy sessions were by Zhu Qingshi [Qinghai Institute of Salt Lake and Luda (Darien) Institue of Chemical Physics] and co-workers on LIF of the $A^2\Pi - X^2\Sigma$ transition of CaOH using a single mode ring dye laser to determine accurate rotational constants which will be employed in a microwave search for interstellar CaOH, and a tunable infrared diode laser study of Fermi and Coriolois interactions in the CH_3I *vs.* fundamental. Kinetics measurements of the potential chemical laser reaction Sn (^{3}pj) + $N_2O \longleftrightarrow SnO^* + N_2$ by Wang Xiuyan [Luda (Darien) Institute of Chemical Physics] and co-workers found that the Sn ($^3p_1$) spin-orbit state reacted eight times faster than the Sn($^3p_{0,2}$) states. This work was performed in a high temperature fast flow reactor (HTFR) and also yielded spectroscopic constants for five lowest lying spectroscopic states $X^1\Sigma^+$, a $3\Sigma^+$, b, b′, and $A^1\Sigma^+$. It was noted that Ar quenched the a state more efficiently than the b state.

A paper on the laser and optical probing of the crossed molecular beam reactions of Ba (^{1}S and ^{3}D) with CH_nCl_{4-n} (n=0,1,2) and $C_2H_{6-n}Cl_n$ (n=2,3,4) was presented by Dong Linna and co-workers [Luda (Darien) Institute of Chemical Physics]. LIF of the BaCl $C^2\Pi_2 - X^2\Sigma^+$ system was used to probe the BaCl $X^2\Sigma^+$ product. The results indicated a very low yield from the Ba (^{3}D) + CCl_4 reaction. Chemiluminescence spectra of CCl_2 (A - X) and BaCl ($A^2\Pi$, $B^2\Sigma^+C^2\Pi$) were observed in the Ba (^{3}D) + CCl_4 reactions. In general, their results showed much lower yields of chemiluminescent products from reactions of Ba (^{1}S) relative to BA (^{3}D).

Shen Zhongxin (Fudan University) reported the formation of Pt, Au, and Mo silicides by irradiating P=type Si (111) coated with 400-→ 5700 A^0 thick films of the metals (+ZrO_2 AR coating) using a Q-switched Nd:YAG laser (1.0 kW at 532 nm, 50 μm spot size). In work performed at EPFL Switzerland, Qiu Mingxin (Shanghai Institute of Laser Technology) used the 454.5, 514.5 (and 257.3) nm Ar^+ lines for photo- and pyrodeposition of Sn and Pt onto carbon or quartz surfaces. The ultimate resoluton obtained was 0.2 μm. In a poster paper, Li Fuming and co-workers reported the Ar^+ laser enhanced etching of GaAs and Si substrates (both doped and undoped) using liquids etchants (KOH, H_2SO_4-H_2O_2, H_3PO_4-H_2O_2). Most of the effects were attributed to thermal mechanisms with 50 to 100 μ/min etch rates. However, direct photo enhancement was observed for GaAs/H_2SO_4=H_2O_2.

Harmonic generation and sum frequency mixing in an organic crystal, L-arginine phosphate, was reported by Zhongke and co-workers (Institute of Crystal Materials, Shandong University). The crystal has good UV transmission and large optical nonlinear coefficients. The SHG efficiency was 3.5 times greater than that of KDP for 0.532 μm radiation.

CONCLUSION

The general impression of this participant was that much of the Chinese work presented at this conference indicated notable progress in areas previously established in the non-Chinese literature. The research areas where the Chinese community appears to be making its strongest impact is in materials development (particularly rare-earth containing compounds) and low power clinical applications of lasers.

HIGHLIGHTS OF THE U.S.-CHINA COOPERATIVE PROGRAM IN BASIC SCIENCES AND VISITS TO SELECTED AUTOMATED FACTORIES IN JAPAN

Nicholas Perrone

INTRODUCTION

The writer was a member of a delegation of scientists who visited China through the aegis of the U.S.-China Cooperative Program in Basic Sciences which was supported by the National Science Foundation International Programs. The visit was conducted from 1-13 September 1983, in Beijing and Luda (Darien). In the latter city, a workshop was held on the Advances in Computational Engineering Mechanics through the auspices of the Luda Institute of Technology. Comments, reactions, and assessments as a result of this joint participation in science are provided.

- Beijing Institute of Mechanics

The Institute of Mechanics at Beijing was organized in about 1956 by Dr. H. S. Tsien, a well-known colleague of Dr. Theodore Von Karman. The director is Professor Chen Zge-ming. The original as well as the current primary mission of the institute is in fluid mechanics. About 80% of the effort there is experimentally based.

There are about 20 institutes in Beijing and about 120 research institutes in all of China. They are administered by the Chinese Academy of Sciences. They do use peer review in the same spirit as the National Science Foundation does in the U.S. for distribution of their funding. In addition, Dr. Chen made mention of a contract research program which had just started during the past year. The program is government-administered and approximately 10% of the total research funds are provided this way; however, the program is expected to expand significantly.

Although the institute is primarily fluids-oriented, most of the research work examined there tended to be directed towards solid mechanics. Perhaps the reason why solid mechanics work was emphasized is that it was perceived as being more in line with the interest of the visiting delegation. The institute has a total complement of about 500 people, including support staff.

Visits were made to various laboratories at the institute. The laboratories efforts included studies related to fatigue, fracture, polymers, composites, plasticity, and the dynamic and impact phenomena. They are doing a number of interesting studies primarily on steels in dynamic material phenomena including explosive fabrication and forming, penetration mechanics, explosive welding, and dynamic response of granular media including rock and coal.

While the experimental facilities and equipment appeared competent, current computational power was not great. Apparently, because of the cultural revolution, many of the investigators were 50 years of age or older. In summary, work being carried out at the institute appears to be at a very capable level and covers a diverse segment of solid mechanics.

An invited seminar was also presented at Beijing at the General Research Institute of Building and Construction. The topic of the seminar was the use of interactive graphics to solve a wide variety of structural mechanics problem. This institute carries

out experimental work on various structural configurations and materials. Dr. Chen Jian-he, Deputy Chief Engineer at the institute, was present as was Dr. Tien T. Lan from the Chinese Academy of Building Research.

- The Workshop at Luda (Darien) on Advances in Computational Engineering Mechanics

This workshop was comprised of 12 U.S. scientists as well as approximately 65 Chinese scientists from various parts of China. The topics covered a broad range of areas including optimization, for which Luda is well-known, sub-, trans-, and supersonic fluid mechanics, fracture mechanics, nondestructive evaluation techniques, structural integrity, finite element techniques, and multiphase problems. With such a broad topic coverage (which was the essential theme of the workshop) it was difficult to develop dialogue with Chinese scientists in some of the specific narrow problems being treated. Fortunately, English was the language of the workshop and most of the participating Chinese scientists spoke it very well.

Some survey information was provided as part of the workshop handouts which included a technical report from the China Ships Scientific Research Center on numerical ship hydrodynamics and a report from the Research Institute of Engineering Mechanics of the Luda Institute of Technology. These reports, as well as the papers themselves, display a good solid capability in analytical and experimental mechanics. The advent of a number of IBM and Honeywell computers, which are being provided to China through the International Monetary Fund, should have a major impact on their analytical work in numerical mechanics, especially those studies pertaining to finite elements. From discussions conducted during the workshop, it is clear that finite elements is being heavily emphasized both from a research and educational viewpoint in universities at both the undergraduate and graduate school levels.

The format of the sessions at the workshop was such that only a few papers were presented in the afternoon sessions at which time more extensive, detailed discussions could be conducted on the results of the morning session papers. U.S. guests were partitioned into three parallel afternoon sessions which appeared to be for the purpose of developing a closer dialogue among larger groups of Chinese and a smaller number of American scientists in narrow, focused areas.

- Workshop Presentation by the Writer

At the workshop, this writer presented a paper which discussed the use of finite difference techniques to solve general nonlinear problems with both regular and irregular mesh distributions. Fundamental concepts relating to the techniques were discussed as well as a number of application examples which ranged from membranes to shell structures. In the afternoon discussions, amplification and interest was expressed in the novel and efficient procedure used to solve systems of nonlinear simultaneous equations (with a technique termed the nonlinear relaxation method, which is a modified form of a Newton approach).

- Interpretive Comments

Despite the burdens of a decade of cultural revolutionary upheaval and the fact that this government started in 1948, remarkable progress is evident in the country, economically as well as scientifically. Work in mechanics and other sciences is clearly in a rapidly improving mode. The imminent arrival of a number of high-speed large computer main frames should greatly assist the Chinese numerical mechanics

community, which is doubtlessly somewhat behind scientists in the same field in the U.S. However, the gap should close fairly rapidly during the next three to five years as evidenced by the surging activity in China in computational and numerical methods in mechanics.

The scientists with whom we interacted appeared to be very pleased with the new government contract research program. They assessed it as being more objective than the peer review system which provides funds for the bulk of their studies. It was inferred by some of the participating scientists that the peer review system is somewhat perfunctory, while the contract research program is more defined and better focused.

It would appear that follow up workshops or collaborative research efforts with the Chinese would be extremely worthwhile. For example, areas of optimization, finite element techniques, or numerical methods in solid or fluid mechanics work which might be of significance could include experimental work going on in China in concert with analytical work being done in the U.S. In summary, expanded and continuing interactions between the Chinese and American scientific communities in the area of engineering mechanics is definitely recommended.

VISITS TO SELECTED AUTOMATED FACTORIES IN JAPAN

On 12-13 September 1983, the International Conference on Advanced Robotics ('83 ICAR) was held in Tokyo, Japan [*Bulletin*, *8* (4), 77 (1983)]. It was co-organized by the Society of Biomechanisms, Japan; the Robotics Society of Japan; and the Japan Industrial Robot Association. Subsequent to the conference, a tour was arranged by the conference organizers of a spectrum of Japanese factories in which robotics and/or automation is being utilized.

The tour covered nine facilities distributed roughly between Tokyo and Kyoto within a six-day period. Tour visits included the following facilities:

- Tsukuba Science City (Ibaraki)	To examine robotics-related aspects of the Mechanical Engineering and Electrotechnical Laboratories of the Ministry of International Trade and Industry (MITI).
- Amada Machine Tool Plaza Isehara (Tokyo)	Features a variety of machine tool systems including a sheet metal flexible manufacturing system (FMS) line.
- Fujitsu Fanuc Kanagawa Prefecture	Makes numerically controlled (NC) motors and robots with minimal manpower.
- Dainichi Kiko Yamanashi Prefecture	Manufactures a variety of industrial robots.
- Nissan Shatai Uji (Kyoto)	Assembles various types of autos.
- Komatsu Arc Welding Osaka	Does arc welding of heavy construction machines via industrial robots.

- Daifuku Machinery Works Osaka	To examine unmanned handling systems along with a very small FMS system for varied parts production.
- Brothers Industries Nagoya	To examine sewing machine production including a rather large flexible manufacturing system (FMS) set up.
- Nippon Denso Nagoya	Makes millions of automobile gauges, filters, and other components using a flexible high volume manufacturing system.

The tour was timed to finish in Nagoya on the morning of September 22 which coincided with the beginning of a major flexible manufacturing system (FMS) show also being held in Nagoya from 21-26 September. A flexible manufacturing system (FMS) is a key component of the factory of the future (or even of the present). The FMS is usually related to the automated production of mid-volume (approximately 100-1000 per machine) centers and including an automated work piece handling system all controlled by a central computer. Such systems can cost between $3.0-$20.0 million to set up and usually require a time period of from one to three years to implement. About 40 such systems are in use in the U.S. with an equal number in western Europe and about 60 in Japan.

Despite the fact that there were about 130-140 exhibitors and the show was titled an FMS show, only about ten FMS units had any visibility, and some of them were via graphic displays. During the factory visits only four FMS units were seen in operation.

- Tsukuba Science City (Ibaraki)

Tsukuba is located about 40 miles northeast of Tokyo in Ibaraki Prefecture. Tsukuba is the new Japanese Science City developed in the late seventies to foster new government technology initiatives. It will be the site of an exposition in 1985 and houses the Mechanical Engineering Laboratory and the Electrotechnical Laboratory which fall under the auspices of the Agency of Industrial Science and Technology of the Ministry of International Trade and Industry.

At both the Mechanical Engineering Laboratory (MEL) and the Electrotechnical Laboratory (ETL) forty-five minute briefings were presented along with films. Both groups concentrated on robotics-related activities. One got the feeling that they were not showing us their most up-to-date projects. Many presenters spoke very poor English.

. Mechanical Engineering Laboratory (MEL)

The MEL has about 220 people and is working on about 100 different projects. The average life of each MEL project is about three to four years with two to three people working on each area. It was suggested that a project is dropped after that period of time.

MEL is about one-fourth the size of ETL with a budget in 1982 of $11.0 million versus $39.0 million for ETL. Aimed towards furthering Japan's machine industry, MEL has been carrying out R&D efforts on advanced as well as basic technologies. Principal focal efforts are in resources in energy, and production engineering.

MEL's 220-person research staff are grouped into departments of basic engineering, systems science, machinery, materials engineering, production engineering, and automobiles. MEL showed a film which was not particularly up-to-date including a six-legged walking robot, a seeing eye robot, a precision manipulator (including insertion and working at fairly close accuracies of less than 1 mm), and an omnidirectional robot which ran on guided wheels.

Actual demonstrations showed a very small six-legged robot which could only go in two directions, but with significant payload capability. Four of the legs were always on the ground at a given moment. A larger, more sophisticated robot was also shown which had a turning capability. Finally, a wall-climbing robot was shown which could walk on rough terrain. It consisted of vacuum cups which exerted a force of from 7 to 14 kg, depending on the surface. This small robot had a normal pulling force of about 77 kg. Its intended applications would include working on the sides of ships for painting or reconditioning. This project had been underway for about two years. MEL also has a large FMS project involving laser systems.

. Electrotechnical Laboratory (ETL)

Important areas covered by the ETL include electronics, information processing, energy, and national standards. Its 565 research workers are partitioned into about 13 divisions; the ones which are concerned with robotics are in computer science and automatic control. Some of the robotic-related work included the following:

- direct drive robots,
- simplified programming approaches for robots,
- force control sensing systems, and
- Vax to microsystem communication interaction.

Under the category of vision-related work are the following:

- recognition of scenes from high-contrast features,
- ability to zoom in on uncertain objects in a scene,
- use of striped light to discern object's shape, etc., and
- assessment of dynamic motion scenes.

Some of the demonstration exhibits included a system called the Language-Aided Robotics Teleoperating System or LARTS. This was not a particularly impressive display as it did not appear to demonstrate a significant functional capability in teleoperated systems. Dynamic motion scene assessment was being worked on. Purportedly, its purpose was to assist a seeing eye robot to know what to interpret when it came across various objects, including moving people. They are hoping for real time processing somewhere in the future. This capability would obviously be of use in a factory environment if it were developed. A brochure on the "FMS complex with laser" was given but not any further useful information on its status.

Questions to companies seen subsequent to the MEL and ETL visits did not seem to suggest that industry was looking at the MITI laboratories for technology development guidance. While the laboratories do claim this lead area in industrial interaction, one does not get that same signal back from the industry groups.

- Amada Machine Tool Plaza (Isehara)

We visited the Amada Machine Tool Plaza in Isehara (outside of Tokyo). This company originally started by obtaining licenses to market and then make various imported machines. They now make most of the machines themselves including sheet metal working, grinding, electric processing, milling, shearing, punching, laser, etc. They have even begun to market a complete turnkey sheet metal FMS system. It costs $2.0-$2.5 million and is used primarily to make electronic packaging boxes of various sorts. A demonstration of the operation of the FMS system was provided during the day's events. It uses carts which are driven by electric signals under the floor. Prospective customers, who have a particular machine tool or set of tools they expect to buy from the company, come to this extremely large plaza to try out the tools as well as to receive training for their personnel. Amada Company employs about 3400 people. It has already sold four FMS systems to Japanese manufacturers but none overseas yet. It has numerous licensing arrangements with companies such as Brown and Sharp, Bridgeport, and Mandelli (from Italy). They have evidently adopted a vigorous open-minded publicity campaign encouraging people to come into their facilities and examine their operation extensively. Photographs are permitted which is not the typical situation for most people in the robot and machine tool industry. This approach appears to be worthwhile.

- Fujitsu Fanuc (Kanagawa Prefecture)

A visit was made to the Fujitsu Fanuc factory. A general briefing was given along with a film showing and literature was provided about the company. Fanuc's progress has been phenomenal. It was formed in the early seventies with main shareholders being Fujitsu, Ltd., Siemens AG, and Fuji Electric Company, Ltd. It is located at the foot of Mt. Fuji and consists of two principal divisions: motor manufacturing and mechatronics (microelectronics and mechanics) manufacturing along with a technical training center. The motor manufacturing division has approximately 60 employees using 101 robots to produce 40 different kinds of control motors at the rate of 10,000 units per month. Machining is done for 900 varieties of motor parts in lots ranging from 20 to 1,000 units. The second floor of the building houses the assembly cells. There are four assembly lines containing 25 assembly stations with 49 robots. In the mechatronics manufacturing division, 100 employees produce 300 robots, 100 wire-cut EDM (electron discharge machining systems) and 100 mini-CNC machine tools per month. There are 450 different types of parts or machines in lots ranging from 5 to 20 units. During the last decade the company has grown from about 620 to less than 1000 employees. During that same period of time, gross revenues have increased more than tenfold to $375.0 million and net income is about 33% of sales. This means that the sales volume is $375,000 a year per employee, a phenomenal accomplishment. There also appears to be much room for further growth and expansion without significant addition of employees. Photographs were not permitted in the factories and the assistance provided by the Fanuc personnel was virtually nonexistent in the way of information on company operations and use of the robots. Fanuc has many subsidiaries throughout the world with the largest one being in Michigan in combination with the General Motors Company (General Motors Fanuc, GMF). The primary purpose of GMF is sales and distribution, not for R&D.

- Dainichi Kiko Robotics (Yamanashi Prefecture)

We next visited a company named Dainichi Kiko Robotics. This company makes a wide variety of articulated robots with payloads from small to rather large. Products even include a high speed palletizing system which is being done in concert with a Swedish company at the plant in Yamanashi Prefecture. The company also provided the

visitors with a film on robots which included the social aspects of robotics. No photography was permitted on the factory floor which was, in fact, more like a large sales area. Prospective customers evidently go there to try out possible robot approaches and also engage in collaborative R&D projects with the company to see if the robots would be useful in their operations. Though they claimed capability in the areas of vision systems, they did not describe much about it, nor do any of their robots have working vision functions. They professed little or no interaction with MITI laboratories nor any desire to do so.

- Nissan Shatai (Uji)

The Nissan Shatai plant at Uji, which is outside Kyoto, was visited. We were shown a film (in Japanese) and were also permitted to walk through the assembly line. The Nissan Shatai plant is separate from the other Nissan motor group activities; engineering development is, however, common to all of them. Sales being produced from this plant are very considerable in light of the number of employees. Sales volume is approximately $285,000 per employee, which compares very favorably but is slightly less than the Fanuc plant. In view of the small amount of automation which exists in the plant, this number is amazingly high. Only a limited number of spot welding robots are evident in the plant. They represented about one-third to one-quarter of the total spot welding activity. Almost all other operations were traditional transfer line techniques with all the work being done by people. One obvious big cost saving is in the very low inventory level. They estimated only 1.5 to 2 shift amounts of parts were available at any given time. The suppliers, many of whom are subcontractors, are obviously making deliveries to the plant almost on a daily basis. The few robots that appeared to be in use were from Kawasaki and Unimate. Workers are currently working a nine-hour day which includes one hour of overtime. Once a year, employees receive a bonus of equal to about six-months salary. The average 32 year-old male worker makes about $1,000 per month without bonuses. An inspection of the plant suggests that the workers are doing repetitive, tedious, monotonous work, but are apparently still producing efficiently and effectively. They work for two hours on the assembly line and ten minutes off. In some parts of the line, especially the noisier ones such as where spot welding and manual welding operations are being conducted, intermittent music is turned on along with chimes when the line is to move along to the next step. Their decision on when to bring robots in is based on many factors, among them being the return on the investment, which they determine to be about a three-year period. They claim their paint shop is entirely automated but would not let us see it and did not explain why.

- Komatsu Arc Welding (Osaka)

We visited the very impressive Komatsu Arc Welding plant located between Kyoto and Nagoya. Komatsu does about $2.5 billion a year in sales, and has an extensive R&D department encompassing soil mechanics, finite elements, noise, sensors, and field tests. They export to approximately 130 countries and have won the prestigious Deming Award twice. They have 40% of the world market exclusive of the U.S. market. The arc welding robot is designed in the Osaka plant. They use it only for standard steels and not high chromium steels. Both Cartesian and articulating robots can use this system. Prices of the welding robots range from about $100,000-$150,000. They have sold about 100 units. The company makes numerically controlled (NC) tools along with all types of heavy-duty excavating equipment, engines, steel, and presses. They also have manufacturing plants in Brazil and Mexico. Some of their more recent novel products include remote control vehicles, which work in difficult environments such as slag processing, hauling jet aircraft on runways, amphibious engines for marine operations, and underwater survey

vehicles which are being used for exploratory work off the coast of Japan and for bridge footings.

The body weight of the excavating unit is from 10 to 22 tons. Roughly, 14 sections exist along the assembly line. Each section operation is about 43 minutes. Twenty-six people are assigned to each line with 13 on the main line. Thirteen also work on subassembly lines. Each worker has a specific set of tasks to do. Error is still possible so that inspections are evidently staged along the way to correct such problems. The quality control is integrated right into the assembly line itself. For example, one of the most critical parts of the excavator is oil leakage prevention. The piping system is checked to be sure that such leaks are not present. Production is about 350 units a month.

Another unit being assembled is a 70-ton bulldozer which is claimed to be the largest made in the world. They produce about 10 units of this massive bulldozer each month. These are not assembled using the transfer line technique but rather with air pallets that move them from one station to another. It is a ground control vehicle with a cushion of air under the pallet which permits it to be moved about easily because of the low frictional force. Essentially, a single man or laborer can push an 80-ton unit in this manner. Komatsu is the first company to introduce such palletized systems, although this system is now more prevalent elsewhere. This air support system is also used in stadiums where large numbers of seats or perhaps even dome structures are moved. The floor system has guidance for Komatsu-designed unmanned forklifts which transfer materials from and to the machine section.

. Sheet Metal Shop

The machining centers are numerically controlled. Their philosophy is to continue to try to minimize labor wherever possible.

. Bulldozer Assembly Line

It is about 200 meters long and the units weigh about 23 ton. Seventy-five people are assigned to 25 different stations. Machine transfers are done in an automated manner; twenty-three minutes are alotted for each station. Quality control is taken care of along this line by the workmen themselves. The work is checked after each section stop of the unit. The final inspection is a reconfirmation of all the inspections that were to have been performed. The factory is extremely clean, appears orderly, with all the functions being carried out in a timely and apparently efficient manner. There appears to be but one person working on each unit at each of the stations. There are about 50 units on the line based on a quick estimate. From early indications of their 74 people on the assembly line, these numbers would appears to be correct. All the work is done manually with pneumatic drills or tools. The line is largely for assembly. The workers were occasionally observed entering notations into a record.

. Robot Area

A KVX55 Cartesian system was used to automatically arc weld a very heavy duty part. Another large automatic welder was adjacent to it; it also does welding and these two units perform 30% of the welding required. The components are first tack welded by people and then subsequently placed into the automated system where the computer program resides and complete, continuous welds are then made for the entire component.

During the question and answer period, it was indicated that 45% of the welds are done by the robots. About 50 robots have been sold outside Japan. Controllers are made entirely by Komatsu, both for the arc sensing and for operations. Welding wire is positioned with respect to component by monitoring the amperage through the arc. The arc burns about 10% of the time on the automated robot. They use "just in time" production. Sixty percent of the components are made outside the company and are delivered on a daily basis. Tack welding does not interfere with the continuous welding process. Also an optical sensor assists in the initial positioning of the weld point. It is anticipated that each robot will replace three or four people.

- Daifuku Machinery Works (Osaka)

We visited Daifuku Machinery Works, a materials handling system company in Osaka. They have about 1600 employees and about $200.0 million annual sales. Their products are divided into two groups. One is large-scale equipment for material handling. They make small-scale instruments which are manufactured elsewhere. The main object is the integration of materials handling. They are involved in all kinds of automation of the factory which includes FMS. Forty percent of the company's products are produced in this plant. Two, they make conveyor systems for automobile plants and nuclear plants. Two hundred and twenty people are involved of which 100 are in the engineering division. One hundred people work on the assembly line, 20 of whom are managers. Many of the automatic systems they manufacture are exported. Customer groups include automotive companies and electronics companies. Daifuku uses robots mainly for welding operations. They are trying to integrate their system by using the CAD approach, and they do have a requirement here for manufacturing small batch size items. They produce a computer-aided design of the system which has an automatic parts delineation. It uses a MELCOM computer. The software for the CAD package is done internally. They have, evidently, a sketchpad input with a zoom capability.

. Plant Tour

A bank of five robots performed a series of welding operations in a fixed and jigged mode. The material was loaded and unloaded by the workers. The robot demonstrated an in-process manipulation of small parts, a form of assembly or palletization was being shown. The robot can move as can the platform on which it is operating. Most workers in this factory worked in a manual mode as the number of robots is limited. An automated storage facility was shown where information that is stored in the various bins is computer-managed and these bins can be retrieved or restored automatically. We next examined their FMS system. The FMS system has four machine tools and a single cart. They use it to make conveyor components of a wide variety in small batch lots for internal use. The FMS system replaces about eight people. A loading table was evident where parts were automatically fed into a component feeder. It was quite impressive that a company of relatively modest size such as theirs would have an operating FMS system. It obviously increased their efficiency appreciably.

- Brothers Industries (Nagoya)

The host at Brothers Industries (outside Nagoya) was Mr. Sukiyama, Production Manager. The company has annual sales of about $620.0 million; about 5% of their sales is alotted for R&D efforts. Their cost for a manyear including overhead is about $40,000. The company has about 5000 employees, with half being in manufacturing. About 1200 employees work in planning development and general administrative activities. The company was founded in 1935 as the Japan Sewing Machine Company.

The initial products were straw hats. Until 1947 to 1948 they produced sewing machines. They began marketing refrigerators in 1953 as well as sewing machines. In 1958, they began production of knitting machines and, in 1961, typewriters. In 1961, they began marketing machinery of various types. The latest model of a transfer machine was made some seven years ago and is still operating.

The first design for FMS began in 1977. In 1977, production also began on impact printers. Subsequently, most typewriters and sewing machines have been equipped with microcomputers which are battery operated.

The FMS system began operation about three years ago in 1980. The system makes about 3500 sewing machines a month. The raw material required is cast iron. Seven different models are made at this time. The 2500 units are essentially of the seven different models. About six years ago, the sewing machines were produced at the rate of about 600 or 700 units a month. Since then, productivity has increased three- or fourfold or even more. Each machine is installed with NC (numerically controlled) systems.

Different manufacturing functions are located on each floor. One floor includes painting activity; another floor has assembling activity; a third a different function. The bottom floor is devoted to FMS. Painting is done mainly through an electrostatic process. Castings of various sewing machine parts were on pallets for ready transport. Units are moved along by a conveyor belt system. Parts were assembled, on a conveyor belt system, two at a time and automatically electrostatically painted. The painting process itself is performed by a robot. Painting is done in a closed room using the conveyor belt system. A worker monitors the process. The electrostatic paint process causes little waste and produces even distribution of paint on the item being painted. As the conveyor belt moves, the items are turned and a second robot in an adjacent stall paints the back surface. Items are then baked in an oven.

Total floor space is approximately 24.4 m by about 61 m. In about 4575 m^2 and with 15 workers, they produce their entire product line.

The next floor is a testing area. Various tests are conducted on the machines from many angles such as their efficiency, safety, ease of use, and durability. After machines have been completed by assembly, certain tests are made at random during the final inspection. Insulation and high voltage resistance tests are conducted; for example, machines manufactured for domestic use, 1200 V is applied for 1 second; likewise for the U.S.A. and Canada, whereas for Germany a 4800 V test is applied. The items are moved from this test area for shipping and packing; they are actually fully assembled here. Sewing tests are conducted including 14 different tests with each stitch pattern checked for neatness and uniformity. This assembly and testing area clearly has the greatest number of people (about 60). There are four lines. The length of each line is about 45.8 m and includes 34 processes.

. The FMS System

At the FMS factory, the castings are dispatched by a system of carts to a number of different stations. There are 25 different stations with about eight different carts. The carts are not on a closed loop, but rather run on three different tracks. (One car being on one track, three on another and another three on a third track.) The carts take the castings from a conveyor line and inject them into the different machining operations. The parts are placed onto the conveyor line manually. They are stacked in bins for loading. Only two people with 24 machines operate the entire assembly line. The

assembly line has an overall length of about 53 m. Its capacity is a little more than 3000 units a month. An automated machining line for the arms makes about 35,000 units a month; it takes 15 seconds for each unit, and has an overall length of about 45.8 m. Two people with 19 machines operate the entire process.

DNC control with information from the computer is communicated to each machine in the FMS line. The cost of the installation of the FMS system was about $2.5 million and took two and one-half to three years to install. The investment return to the company was anticipated as being about three years.

The system permits a number of mixed parts to be manufactured in the line, but they all relate to the industrial sewing machine production line. About one-third of the industrial sewing machine components are made on the system. The reliability of the FMS system has been extremely high with minimum downtime. Its actual operational efficiency is about 90%. The $2.5 million cost estimate for the system includes hardware and software, approximately equally divided. It operates for two shifts from 8 a.m. to 10 p.m. Should changes in the programming be required, it takes a one-month programming implementation and another month for tooling implementation.

- Nippon Denso Company (Nagoya)

The Takatana Nippon Denso plant outside Nagoya has about 4600 employees with 46 acres of floor space. It has a robot which assembles automobile display panels that was developed here. The company has annual sales of $2.5 billion or about $100,000 per employee. They especially try to use robots in environments which are difficult for humans to work in, and also in simple processes which are readily suited for automation. High productivity and quality control are also considered important. One of the first areas where they used robots was in a die casting area which is very hot and uncomfortable for people. Currently, about 1500 employees work on machine tools.

Robotics research started here some 18 years ago. Thirteen years ago robots were first used in the die casting area. They have been developing robotic systems for assembly purposes. The company makes about 3000 different products. Nippon Denso employs a flexible high production system for engaging in process inspections used in almost all components. The company spends considerable effort on R&D; areas include semiconductors, display mechanisms (liquid crystals electroluminescence, optical fibers), solar batteries, materials (FRP, ceramics). They produce integrated circuits (IC), including automatic assembly or circuit boards, and also have a flexible automated production system. They have automatic process inspection of a variety of parts being produced in very high volume. For some in-process monitoring they use vision systems. They produce about 500,000 units a month for each shift. As evidenced by the film which was shown before the visit to the factory, a remarkably high volume, flexible automated manufacturing capability existed in the company. The system includes assembly, a very complex field. However, when making the visit to the factory, it was apparent that there are still a lot of people involved in the process, doing tedious, monotonous work. The worker remains at the same station during the entire day. A question raised was: Why does the company not have more automation considering the repetitive nature of many of the tasks? The response was that the Japanese people are extremely good workers, and it becomes economically difficult to replace them with robots. The employees work a full eight-hour day with ten minutes off in the morning and afternoon and a 45 minute lunch break. During the breaks in the morning and afternoon they take two or three minutes for exercise periods.

STEELMAKING JAPANESE STYLE - VISITS TO NIPPON KOKAN

Harry I. McHenry

Nippon Kokan (NKK) is an integrated, heavy-industry company engaged in steelmaking, shipbuilding, construction, and engineering. NKK is the second largest steelmaker in Japan and has two integrated steelworks. The Fukuyama Works is the world's largest with an annual capacity of 16 million tons. The Keihin Works has Japan's newest integrated steel mill called the Ohgishima Project. The 6 million ton capacity Ohgishima complex was completed in 1979.

In this report, visits to the Fukuyama Works, the Keihin Works, and the Technical Research Center are reviewed with emphasis on the technologies for the production of ship plate steels. During the plant tours, facilities and operations were observed for pretreatment of the hot metal (pig iron), steelmaking in basic oxygen furnaces (BOF), ladle refining, continuous casting, and hot rolling. Technical discussions were focused on two subjects: impurity control (particularly sulfur, phosphorous, and nitrogen) and thermomechanical treatment (TMT), such as controlled rolling and on-line accelerated cooling.

FUKUYAMA WORKS

The Fukuyama Works are located in Hiroshima Prefecture in western Japan on a 17 million m^2 site that juts into the Inland Sea. It is a modern mill that started operations in 1966; it became fully operational in 1973. Raw materials are unloaded at piers (ten berths) capable of handling ore carriers up to 200,000 DWT. The materials flow from east to west, starting in the piers and proceeding to the raw materials yards, sintering plants and coke ovens, five blast furnaces, three steelmaking shops with eight basic oxygen furnaces (BOFs), various mills (plate, strip, pipe, etc.), and finally to the products piers (22 berths) at the west end of the site. This layout results in the efficient flow of materials from one steelmaking operation to the next.

The production flow chart for steelmaking at the Fukuyama Works is shown in Figure 1. For the production of premium quality ship plate, the operations of interest are hot metal treatment, bottom blowing during BOF steelmaking, ladle refining, and thermomechanical treatments during plate rolling. These topics are discussed in the following subsections.

- Hot Metal Treatment

The hot metal leaves the blast furnace with approximately 0.1% P, 0.03% S and 0.3% Si. About 35% of hot metal is treated to reduce sulfur to below 0.010%. The normal procedure is the KR process developed by Nippon Steel. In the KR process, CaO powder is fed into the transfer ladle and the hot metal is mechanically stirred with a rotating impellar. Calcium carbide powder has also been successfully used in this process, but it is more expensive than CaO and thus not used in production. This operation is done at a station adjacent to the steelmaking shop just prior to charging the BOF. The KR facility is a ladle cover that is equipped with a stirring devise plus ports for flux addition and exhaust gas control.

For low P steel, it is necessary to reduce the silicon content of the hot metal from approximately 0.3% to below 0.1% prior to P reduction. This is done in the runner, the stream of hot metal flowing from the blast furnace to the transfer ladle. Fe_2O_3 is added to the stream to oxidize the silicon.

Phosphorous is reduced by a gas injection process. The gas injection system (GIS) is a ladle cover equipped with ports for adding flux, a lance for injecting gas to stir the hot metal, and an exhaust port for fume control. The GIS facility is located next to the KR facility.

Two options are available for reducing phosphorous. First, there is the combined (P and S reduction) treatment using soda ash. With this method, P is reduced below 0.01%, and simultaneously S is reduced below 0.01%. Second, there is a two-step procedure in which the KR process is used to reduce S, and then gas injection stirring with a CaO and CaF_2 flux is used to reduce P below 0.01% and S below 0.001%. The two procedures have been evaluated in the Fukuyama Works over a three year period. The two-step procedure is preferred because the soda ash treatment attacks refractories. In addition, soda ash is more expensive than lime (CaO) and must be recycled.

- BOF Steelmaking

All steel produced by the Fukuyama Works is made by the BOF process. For plate steels, the combined blowing (NK CB) process is used. Combined blowing refers to the use of top and bottom blowing during refining. Top blowing is done with a multihole lance which is needed to provide the large volume of oxygen required by a 250-ton BOF. Bottom blowing is typically done through four plugs. The bottom blowing is used for stirring the charge and for control of the nitrogen content. Bottom blowing with oxygen, which speeds up the refining process, is not used by NKK.

The gas used for bottom blowing is selected depending on the desired nitrogen content. Argon is used to produce low N steels, e.g., steel plates for low temperature service. Nitrogen is used to control N content, e.g., steel sheets for automobile bodies. Carbon dioxide may be used in place of argon to reduce gas costs. Combined blowing is best suited for the production of steels with low carbon, nitrogen, phosphorous, and oxygen contents.

For the production of steels with low P and N contents, low temperature tapping of the BOF is used. Temperature is lowered by adding iron ore (60 kg of Fe_2O_3 per ton of steel) during blowing. This increases the yield and increases the refractory life. The adequate oxygen content and tapping temperature prepare the steel for a ladle refining treatment which reduces the phosphorous content. In addition, if tapping is done without any dioxidizer, nitrogen pickup is minimized because of the high oxygen content of the steel. Thus, it is possible to use open air tapping during the production of low N steel.

- Ladle Refining

The Fukuyama Works has a wide range of ladle refining capabilities. Facilities include an RH degasser (1977), a ladle refining furnace (1981), and a vacuum slag cleaner (1982). These facilities are used singlely or in combination for the following metallurgical operations:

- reduction of H, C, O, P, S and N,
- alloying and minor chemistry adjustment,
- sulfide shape control,
- temperature adjustment.

Operations such as degassing--the reduction of H, O, N, and C--can be achieved with a single facility, the RH degasser. Final alloying additions can be done within the RH unit and the steel is ready for casting. However, premium quality steels for severe conditions may require multiple operations. For example, processing flow charts for two steel products are shown in Figure 2. From the customer's standpoint, these processes provide improved mechanical properties, improved weldability, and decreased variability. For example, ultralow sulfur steel reduces the susceptibility to hydrogen induced cracking of pipeline steels for sour gas service, and ultralow phosphorous and sulfur improve the fracture toughness of steels for low temperature service. However, from the steel producer's viewpoint, these processes provide economic advantages. In particular, the efficiency of BOF operations are improved by reducing the need for reblowing and decreasing the tapping temperature, which increases yield and extends refractory life. Alloy adjustment and aluminum killing within the RH or ladle refining facilities improve alloy yield and decrease aluminum consumption, respectively. Continuous casting operations are markedly improved by reduction of impurities which tend to cause surface cracking (hydrogen) or internal defects due to centerline segregation of sulfur and phosphorous. Thus, slab inspection and conditioning can be reduced and direct charging is possible. In addition to efficiency improvements, the range of alloys that can be produced using the large capacity BOFs and continuous casters is increased.

Each of these processing facilities is used in the production of ultraclean steel. During oxygen blowing, mill scale (FeO) and iron ore (Fe_2O_3) are added to the converter. This reduces the temperature and controls the oxygen content of the heat, creating conditions that improve dephosphorization. The heat is tapped at a low temperature (1650°C) without addition of a deoxidizer. During tapping, 15 kg/ton of BOF slag is poured into the ladle and 5 kg/ton of sodium metasilicate, $Na_2O.SiO_2$, is added to increase fluidity and dephosporization potential. The ladle is transferred to the ladle refining furnace where the liquid steel is stirred by top-gas injection using argon (800 ℓ/min) for 15 minutes. Next, the slag is removed using a vacuum slag cleaner, a movable suction head that removes the high phosphorous slag in about 10 minutes, thus avoiding rephosphorization. Next the ladle returns to the ladle refining furnace where a lime (CaO) and alumina (Al_2O_3) flux is added. The steel is arc-heated (3-4°C/min) for about 30 minutes to recover the temperature lost during dephosphorization and slag changing, and due to the low tapping temperature. During heating, the steel is stirred with 800 ℓ/min argon. Strong stirring with 2000 ℓ/min argon from a separate lance is used during part of the heating cycle to reduce sulfur by gas injection stirring. After ladle refining, the ladle is moved to the RH degasser, where a 15-20 min cycle is typical. For normal operations 800 ℓ/min of argon flow is used, but if extra low nitrogen is required, the argon flow is increased to 2500 ℓ/min. The higher argon flow will reduce nitrogen from 40 ppm to about 25 to 30 ppm. After RH treatment, the steel may be ready for casting, or may be returned to the ladle refining furnace for final temperature adjustment and or sulfide shape control. The latter is achieved by gas injection of calcium silicide. The CaSi injection must be made after RH degassing to avoid evaporation. Adjustment of the final temperature for tapping into the continuous caster is important for surface and internal quality of continuous cast slab.

- Continuous Casting

The Fukuyama Works has three slab continuous casters and one bloom continuous caster with a combined capacity of 6,000,000 tons per year. The maximum slab cross section is 2.1 m x 220 mm.

An important new development in continuous casting is a mold level control devise. The devise is an eddy-current level meter which, coupled with automatic feedback controls for the tundish slide valves, can maintain a constant liquid level in the mold. This eliminates the main cause of surface defects. It is so effective at eliminating surface defects that slab inspection and slab grinding are not necessary. Thus, it is possible to charge the hot slab directly into the reheating furnace, thereby conserving time and energy. Currently, 40-50% of the continuous cast slabs are directly charged. This percentage is expected to rise as high as 90% in the near future.

- Plate Rolling

The Fukuyama Works has a 185-inch-wide four-high roughing mill and a matching finishing mill with a production capacity of 2.5 million tons. Both mills were installed in 1968 and have a 4500 ton force capacity. The finishing mill is sheduled for reconstruction in 1984 to facilitate severe controlled rolling operations; the maximum load will be increased to 7500 tons.

The slab reheating furnaces are at the head of the rolling line. There are three continuous furnaces and two batch furnaces for slab reheating, which takes about four hours. The reheating temperature is adjustable. High temperatures (1200-1250°C) require more energy, but improve the production rate. Lower reheating temperatures (1020-1150°C) are used to improve fracture toughness. However, if the lower reheat temperature is used, the steel must have been RH degassed to avoid hydrogen problems. In the future, reheat temperatures as low as 900°C may be used. Temperature uniformity is a problem at lower reheat temperature. However, new furnaces (made by Ishikawajima-Harima Heavy Industries, IHI) have a special burner design which results in a constant flame length for all fuel rates. Improved temperature uniformity results.

The slabs pass through a stand of high pressure water jets to remove the scale and then enter the roughing mill. All cross rolling is done by the roughing mill. After roughing, the plates pass through a shower where the temperature is set for finish rolling. Controlled rolling is frequently used and different grades and thicknesses require different initial rolling temperatures.

The roughing mill is equipped with a high speed (50 mm/sec) large-stroke, hydraulic cylinder (made by IHI) that permits yield improvement (about 2%) by a procedure called dog-bone rolling (DBR). The DBR procedure takes place in the final one or two broadside passes in the roughing mill. The plate enters the mill and then the stroke is rapidly increased to the desired reduction. The rolls are quickly separated just prior to completion of the pass. Thus, the front and back (about six inches) of the plate is thicker. These thick ends become the sides of the plate during finish rolling, and provide the added material needed to get a square-ended plate. Thus, less cropping is required and yield is increased. Currently, the slab to finished plate yield is 93%.

The entire rolling operation is computer controlled. This is particularly apparent during finish rolling. The plate proceeds through the step-by-step reductions at

prescribed temperatures. Temperature is adjusted by a spray unit in front of the mill. Each reduction is computed to require the full load capacity of the mill. The operator controls the movement of the plate and compares actual rolling conditions against those called for by the computer. The override function of the operator versus the computer-controlled adjustments for deviations in rolling conditions were not apparent.

- On-line Accelerated Cooling

A recent development of NKK is the on-line accelerated cooling (OLAC) process. After completion of rolling, the plate passes through a special cooling zone (the OLAC facility) where it is subjected to controlled water cooling over a particular temperature range (800°C to 550°C is typical for ship plate) at a set cooling rate (e.g., 12°C/sec). Subsequently, the plate passes through a hot leveler and is then air cooled. After this brief treatment, the plate has properties that exceed the requirements for normalized plate.

The OLAC facility is 4.8 m wide by 38 m long. It is capable of handling plates up to 15 m in length. After the plate is completely inside the OLAC enclosure, spraying is started. The plate continues to move down the line under the sprays. Spraying is stopped at a predetermined time while the plate is still within the 38 m long OLAC enclosure. The plate then passes through a continuous hot leveler and continues on to the various cooling, shearing, marking, and inspection stations.

The OLAC system was observed in operation, but only a general appreciation of the complexity of the plumbing system could be realized. Techniques have been developed which minimize plate distortion. First, the entire plate is treated at one time. Special nozzles are used that can control the quantity of water supplied and that can turn off simultaneously. The upper side of the plate is cooled by a laminar-flow cooling system and the lower side by a spray cooling system. A water quantity gradient is used in the width direction and the plate edges are not sprayed (a gutter is located above the plate edges). The leading and trailing ends are somehow protected against undercooling. The water system for OLAC is independent of the normal plant system. Thus, it is possible to assure adequate control over the quantity and pressure of the water.

The control system for OLAC is based on the assumption that OLAC simply affects the tensile strength of the plate. Toughness is controlled by reheat temperature and controlled rolling practice. A relationship exists between tensile strength and the cooling rate during OLAC processing. A computer program is used to compute the cooling rate required to meet the tensile strength specified for each plate treated by OLAC. The input variables are chemical composition, plate size, reheating temperature, and finishing temperature. The cooling rate, plate size, and OLAC finishing temperature are used to compute the volume of water required. The time to spray this volume of water is computed and used to set the length of the cooling zone within the OLAC facility for a given travel speed. When the plate passes this position (zone number), the water is turned off. The plate continues down the line, through the hot leveler and on to the cooling table.

KEIHIN WORKS

The Keihin Works are located in Kawasaki, just south of Tokyo. It is NKK's original works dating back to 1912. In 1971, construction was started on the Ohgishima site by literally building an artificial island in Tokyo Bay adjacent to the original Keihin Works. On the 5.5 million m^2 island, an integrated steelworks was constructed.

Operations were started in 1976 and the works were completed in 1979. The Ohgishima complex includes the raw material docks and storage yards, sintering plant and coke ovens, two blast furnaces, a steelmaking shop with three BOFs, plate and hot-strip rolling mills, a seamless pipe mill and product piers. The remaining facilities at the original site include various pipe and tube mills, cold rolling mills, and various plating and coating lines. Being a new steelworks, the Ohgishima complex features a streamlined facility layout, a high degree of automation, comprehensive energy conservation, advanced environmental controls, and modern steelmaking practices.

The production flow chart for steelmaking at the Keihin Works is shown in Figure 3. The same operations discussed in the section on the Fukuyama Works were of interest during my visit to the Ohgishima works. These operations are discussed in the following subsections. Care is taken to avoid duplication of details presented previously.

- Hot Metal Treatment

About 65% of hot metal is treated by the powder injection process and the KR process to reduce the sulfur content and, in the case of powder injection, to reduce the phosphorous content. Details were presented previously. Hot metal is transported in the open ladle to the BOF.

- BOF Steelmaking

The BOFs are equipped with circulating lance equipment. All blowing is from the top. The circulating lance is similar to a conventional oxygen lance except that it can rotate at velocities up to 5 rpm in a radius of up to 1.2 m just above the liquid level. The circulating hot spot enhances slag-metal mixing and thus accelerates dephosphorization. It also provides improved control over oxygen and carbon content, extends refractory life, and improves yield when compared with a stationary lance. However, those improvements are greater for combined blowing such as done in the Fukuyama Works. The only advantage of the circulating lance over combined blowing is in the production of high carbon steels, such as seamless pipe for oil drilling--a product made at the Keihin Works. Future plans call for installation of combined blowing at the Keihin Works to be used in combination with the circulating lance.

- Ladle Refining

The ladle refining facilities are similar to those at Fukuyama except that there is also a powder injection facility. At Fukuyama, the functions of the powder injection facility are performed in the ladle refining furnace. The powder injection facility is a ladle cover equipped with an argon gas purging unit and a lance-immersion port. Argon purging is used to lower the partial pressure of oxygen prior to gas injection. After purging, the lance is immersed and argon is used for gas injection stirring to lower sulfur. The same lance can then be used for flux injection to further desulfurization and for CaSi injection for sulfide shape control. After CaSi injection, gas injection is resumed to enhance inclusion removal by flotation. The final levels of sulfur are below 0.001%.

The bubbling station is used for component adjustment and deoxidation of products such as cold rolled sheet. A similar function can be performed by RH degassing.

- Continuous Casting

The Keihin Works has a high continuous casting ratio. There are three slab casters, one bloom caster, and one billet caster with a total capacity of 6 million tons. The slab casters are two strand units which produce 250 mm thick slabs. Slab widths can be varied from 750 to 2300 mm. The bloom caster is a four-strand vertical machine which produces 520 mm wide x 400 mm thick blooms with lengths between 3300 and 4500 mm. The billet caster is a six-strand unit capable of producing billets of three diameters: 170, 210, and 230 mm. A feature of the billet caster is the electromagnetic stirring devices provided at the mold and at the secondary cooling zone. These devices improve surface quality and internal soundness and thus billets can be rolled into pipe without any surface conditioning.

- Plate Rolling

The plate mill at Ohgishima is a four-high mill claimed to be the world's largest. It has an 8000 ton force capacity and is capable of producing plates in thicknesses ranging from 6 mm to 300 mm and widths up to 5.3 m. The annual production capacity is 1.8 million tons. It works the slabs directly, without the use of a roughing mill.

The Ohgishima plate mill is not equipped with an OLAC facility. The mill has several features to provide improved control over plate thickness. The diameter of the backup rolls is 2.4 m and the stiffness of the mill is 1200 tons/mm. In comparison, this mill rigidity is nearly double that of the Fukuyama mill. The mill has a hydraulic automatic gage control system equipped with a roll eccentricity control device. Control over other plate tolerances can be achieved with a hot leveler and a cold leveler. The side and end shears have a thickness limit of 40 mm.

TECHNICAL RESEARCH CENTER

The Technical Research Center consists of a main laboratory complex in Kawasaki and associated laboratories at the principal works. Total employment exceeds 1500 persons. I visited the Kawasaki center twice and had the opportunity to see parts of the structural steels, steelmaking, and fracture engineering laboratories. In addition, I had a quick visit to the Fukuyama laboratories during my visit to the Fukuyama Works. Emphasis during these visits was on thermomechanical processing, and thus, the following is limited to that subject.

The Technical Research Center has a distinguished record of significant contributions to the development of plate rolling into a powerful and versatile thermomechanical treatment (TMT) process. These contributions include developments in the following areas:

- controlled rolling,
- on-line accelerated cooling,
- laboratory simulation of TMT.

These topics are discussed in detail to illustrate the aspects that most impressed me about NKK's research: competence, continuity, and implementation.

- Controlled Rolling

Controlled rolling is a set of hot rolling practices designed to result in as-rolled steel with properties equivalent or superior to those of heat-treated steels. During

controlled rolling, the austenite is conditioned to transform to a fine grain ferrite structure. Thus, strength and toughness are simultaneously improved. This refined structure can be achieved with a lower alloy content than required for heat treated grades of equivalent properties. Thus, carbon equivalent is lower and weldability is improved. It has been used in commercial production since the late 1960s when it was used for the production of plate and strip for large diameter pipelines.

In 1971, Kozasu and coworkers [*Trans. ISIJ* 367, (1971)] at NKK clarified the main features of controlled rolling:

- Range 1: Deformation of austenite above 1000°C is followed by recrystallization and rapid grain growth. The austenite transforms to a relatively coarse ferrite and upper bainite structure. This is the region of conventional rolling.

- Range 2: Multiple pass rolling in the temperature range of 900° to 1000°C refines the austenite grain size by repeated recrystallization. Nucleation occurs at grain boundaries, and thus, a small initial grain size (low slab reheat temperature) results in a finer austenite grain size after rolling. The ferrite grain size is reduced in proportion to the prior austenite grain size.

- Range 3: Deformation of austenite below the recrystallization temperature, below 900°C, creates ferrite nucleation sites within the austenite grains, and leads to a finer ferrite grain size. Microalloying with niobium was shown to be the most effective method of delaying recrystallization, thereby promoting a fine grain size.

Kozasu's paper, published in English in 1971, provides a remarkably clear picture of the metallurgical basis for controlled rolling. Other important aspects were preexisting knowledge, i.e., the effect of carbon and manganese on the transformation temperature, the use of vanadium to provide precipitation strengthening, and the importance of sulfide inclusion control. Subsequent work showed the importance of deformation in the two-phase (austenite plus ferrite) region. This creates additional nucleation sites (deformation bands) within the austenite and provides substructure strengthening of the ferrite.

Research on controlled rolling continues to be conducted by the Structural Steels Laboratory at Kawasaki. The use of controlled rolling as a pretreatment for heat treated steels has led to grain refinement and remarkable improvements in the low temperature toughness of 3.5% Ni steel. More recent work relates to accelerated cooling and laboratory simulation of TMT. These topics are discussed later in this report.

Controlled rolling has been used by many steel producers in Japan to produce literally millions of tons of pipeline steels. However, the use of controlled rolled steels in other applications has been limited by shortcomings in the process. These include:

- maximum plate thickness is 30 mm,
- mill productivity is reduced,
- through-thickness properties are deteriorated,
- code acceptance is limited.

Research during the past ten years has been on accelerated cooling following controlled rolling. This process, discussed below, alleviates many of these shortcomings.

- Accelerated Cooling

Accelerated cooling after rolling is a new thermomechanical processing technique for the production of steel plates with improved combinations of strength, toughness, and weldability. In this process, the plate is controlled rolled with a finishing temperature of 800° to 900°C, immediately cooled at a rate between 3° and 15°C/s to a temperature between 500° and 600°C, and then air cooled.

The mechanism of strengthening by controlled cooling and the rationale for selecting processing parameters have been developed by the Structural Steels Laboratory [Ouchi *et al.*, ASTM STP 672, 105-125 (1979)]. This paper received the Charles Hatchett Award from the Metals Society (London) in 1981. The mechanism of strengthening is simply cooling fast enough to avoid pearlite formation; a fine bainite structure forms in place of the pearlite. Microalloying with niobium increases hardenability, and thus, a higher volume fraction of bainite forms and strength is further increased. Elimination of pearlite has the added advantages of raising the upper shelf toughness in the Charpy test and improving ductility as measured by the reduction of area in a tensile test.

The processing parameters of interest in accelerated cooling are starting temperature, cooling rate, and finishing temperature. In addition, the prior control rolling will largely determine the level of toughness achieved in the accelerated cooled product. The starting temperature should be in excess of the austenite-to-ferrite transformation temperature. Otherwise hardenability, and consequently strengthening, is reduced. The cooling rate should be sufficient to avoid pearlite formation, a cooling rate in excess of 4°C/s is necessary for a 0.12% C, 1.38% Mn steel. Increasing the cooling rate increases the bainite fraction in the microstructure and decreases the ferrite grain size. It is not clear what the upper limit on cooling rate should be; the production equipment is capable of cooling rates of 15°C/s for 20 mm plates. The finish temperature ranges from 500° to 650°C depending on many factors. Finishing temperatures in this range permit use of a hot leveler immediately after cooling, and tends to minimize residual stresses in the plate. High finishing temperatures improve toughness by promoting self-tempering of the bainite.

The accelerated cooling process is highly complimentary to the controlled rolling process. Finishing temperatures above A_{r3} are higher than normally used for controlled rolling, and thus, rolling mill efficiency is increased. In addition, separations (splitting in the through-thickness direction) are virtually eliminated when two-phase (below A_{r3}) rolling is not used. The higher rolling temperatures also make it possible to extend the controlled rolling process to thicker gages. The thickness limit for accelerated cooling is approximately 50 mm for C-Mn structural steels.

Research work on accelerated cooling is continuing at NKK. Recently (1983), a proposal was made to ASTM to permit use of accelerated cooling in lieu of normalizing for ASTM A 537 Class I (C-Mn steel), and in lieu of reheat quenching for ASTM A 553 Class I (9% Ni steel).

- Laboratory Simulation of TMT

Over the past ten years, Ouchi and co-workers have developed two computer controlled servohydraulic machines for hot deformation studies. The original machine, called the "Thermecmaster-Z," has been used for numerous studies, some of which are described below. More recently, a large-scale TMT simulator has been developed [*Nippon Kokan Technical Report, 101,* 117 (1984), in Japanese]. This machine is described at the end of this section.

The Thermecmaster-Z consists of a servohydraulic loading system capable of applying 5000 kg force in tension or compression, a high frequency induction system capable of heating an 8 mm diameter specimen 150°C/s to a maximum temperature of 1400°C, a cooling system that can force cool at rates up to 150°C/s, or control cool at rates less than 10°C/s, an optical dilatometer for transformation studies, a vacuum system and chamber to surround the specimen, a computer for controlling deformation and temperature and for processing data on stress, strain, dilation, temperature, and time. The block diagram for the equipment is shown in Figure 4.

The equipment has been used for a variety of hot deformation studies related to controlled rolling, accelerated cooling, and continuous casting. Studies of hot deformation resistance in controlled rolling are done by measuring the true stress-true strain curve under conditions simulating single or multipass plate rolling (e.g., 40% reduction at a strain rate of 20/s). Multipass rolling is simulated by programming up to eight deformation-time-temperature cycles with specified interpass delay times. In one such study [*Trans. ISIJ*, 833 (1980)], deformation in the nonrecrystallized austenite region was observed to cause a strain accumulation, and consequently, an increase in deformation resistance. On the basis of stress, strain measurements during the multistep deformation, an analytical model was developed to predict mill loads during controlled rolling. The model was verified by the excellent agreement between calculated and measured loads in the production mill.

The change of microstructure during hot deformation and the temperature/time dependent changes after hot deformation can be observed by quenching--in the microstructure existing at a time specified within 0.02 s. The dynamic recrystallization behavior of Nb-bearing HSLA steels was studied by rapidly quenching the steel immediately after deformation to predetermined strain levels. [*Trans. ISIJ*, 543 (1982)]. The results indicate that dynamic recrystallization does not take place at strains and strain rates associated with commercial rolling practices. Dynamic recovery and recrystallization were studied in a 1.8% Al steel [*Trans. ISIJ*, 128, (1983)]. At higher strain rates, typical of the plate mill, only dynamic recovery occurs. Dynamic recrystallization only occurs at slow strain rates, but static recrystallization starts immediately after hot deformation. The rapid quench capability of the Thermecmaster is an essential tool for isolating these events.

The transformation behavior during cooling conditions that simulate plate mill practice can be observed with an optical dilatometer, or with a thermocouple-type thermal analyzer. Continuous cooling transformation (CCT) curves can be obtained as a function of the rolling schedule for the accelerated cooling conditions. The optical dilatometer has been used to show how deformation in the nonrecrystallized austenite region raises the transformation temperature in a C-Mn-Nb-B steel. The thermocouple approach was used to study the effect of reheating temperature, hot rolling conditions and alloying on the γ-α transformation [*Trans. ISIJ*, 214 (1982)].

Tensile testing is useful for hot ductility studies under conditions that simulate continuous casting in a curved unit. Hot ductility reductions at low strain rates can lead to surface cracking in slabs. For Nb microalloyed steels, ductility minima occur between 700° and 900°C [*Trans. ISIJ*, 181 (1982)]. Improvements in hot ductility were achieved by reducing the nitrogen content. Alternatively, problems due to these hot ductility minima can be avoided by hot charging of the slab into the reheat furnace at temperatures above 900°C.

In 1983, NKK completed construction of a large-scale TMT simulator with a maximum load capacity of 150 tons and a maximum ram speed of 1300 mm/s. It consists of a rigid loadframe, a large capacity hydraulic system, a high frequency induction system for heating, cooling nozzles for water and air, and a minicomputer for controlling the TMT schedule and processing load, displacement and temperature data. The block diagram for the equipment is shown in Figure 5.

The machine is designed to simulate plate mill and hot strip mill operations. The dynamic loading capacity is 100 tons at a ram speed of 1000 mm/s. The minimum interpass time between deformation steps (up to 10 steps) is 0.1 s. To achieve a dynamic response that simulates massive production mills required a large hydraulic capacity, use of an inertial mass (8 tons) attached to the ram, and a rigid 4-post frame design. The hydraulic system includes two pumps (90 kW each, 210 kg/mm^2 working pressure), six accumulators (150 ℓ each), and two large servovalves. The maximum discharge capacity of the valves is 3300 ℓ/min. The test specimen (deformed volume) for TMT simulator is 100x100x60 mm. Thus, it is possible to conduct mechanical tests on processed material.

SUMMARY COMMENTS

The Japanese steel industry is well-known for quickly adapting new steelmaking techniques such as basic oxygen steelmaking and continuous casting. It has also been a world leader in jumboizing facilities, e.g., 4000 m^3 blast furnaces, 300 ton BOFs, and 5 m wide plate mills. These advances, coupled with the building of modern integrated steel works with efficient layouts, have given Japan a position of leadership among the world's steelmakers.

All of these features were apparent in the visits to NKK. However, the keynote of the visits was incremental improvement of existing technologies. For plate production, the new techniques that have been introduced into production by NKK over the past five years are as follows:

hot metal treatment for phosphorous reduction,

basic oxygen steelmaking using combined blowing,

basic oxygen steelmaking using a circulating lance,

a new multipurpose ladle refining process: NKK Arc Process,

a vacuum slag cleaner for ladle refining,

a mold level controller for continuous casting,

direct hot-charging of slabs into the reheat furnaces,

dog-bone rolling for yield improvement,

on-line accelerated cooling.

The implementation of these technologies appears to be facilitated by a high degree of technical coordination. The two works interact like a ratchet. One works will try one approach (e.g., circulating lance), the other will use another approach (e.g., combined blowing). Results are compared and the better process is introduced to the

other works, ratcheting up the technology level. There also appears to be a high degree of coordination between the works and the laboratories. Implementation of laboratory developments does not encounter a technology transfer barrier. Judging from the authorship of the related technical papers, the developments listed above are mutual projects of works and laboratory personnel.

ACKNOWLEDGEMENTS

Many employees of NKK kindly provided me with detailed descriptions of their steelmaking practices and their research programs. The author particularly appreciates the generosity, patience, and competence of those listed below:

- Steel Products Planning and Development Department

Hiroyoshi Matsubara, Director
Tetsuo Yamaguchi, Assistant General Manager
Junichi Tanaka, Assistant General Manager, Plate

- Iron and Steel Technical Department

Takayuki Koyano, Assistant General Manager, Steelmaking

- Technical Research Center-Kawasaki

Fusao Koshiga, Assistant Director
Isao Kozasu, Head, Structural Steels Laboratory
Chiaki Ouchi, Senior Research Engineer, Structural Steels Laboratory
Masanori Kawahara, Head, Fracture Engineering Section
Yoshihiko Kawai, Senior Research Engineer, Steelmaking Laboratory

- Technical Research Center-Fukuyama

Yoshio Miyashita, General Manager, Director of Fukuyama Research Laboratory
Tadaaki Taira, Manager, Steel Products Laboratory
Kazuaki Matsumoto, Senior Research Engineer, Steel Products Laboratory

- Fukuyama Works

Kenji Hirabe, Superintendent, Plate Mill
Masaru Ishikawa, Manager, Steelmaking Division
Kazuyoshi Arikata, Assistant Manager, Plate Mill

- Keihin Works

Katsuhiko Tachibana, Manager, Steelmaking Technology Branch

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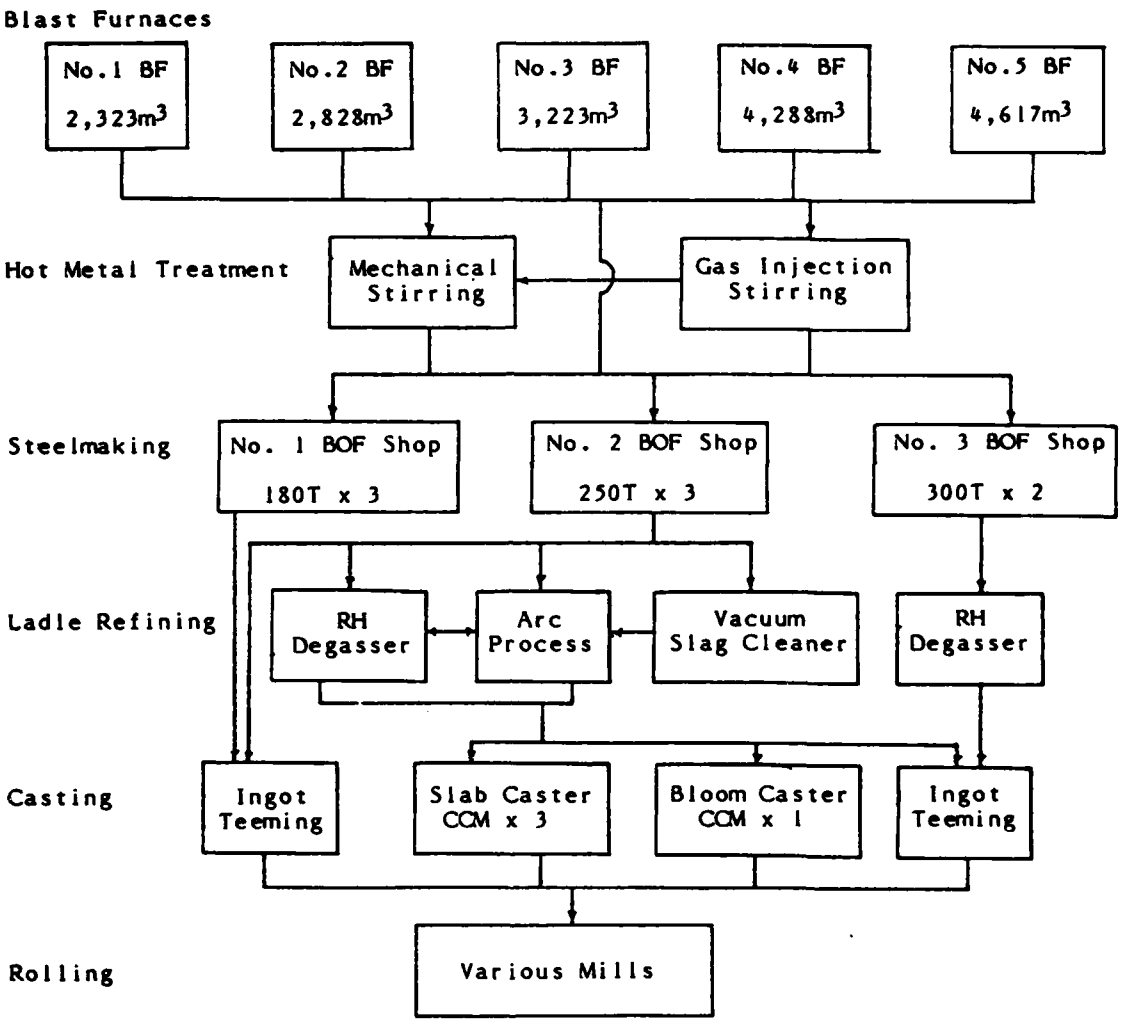
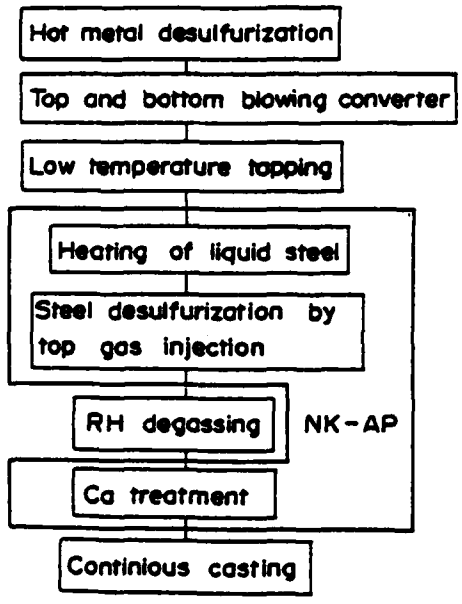
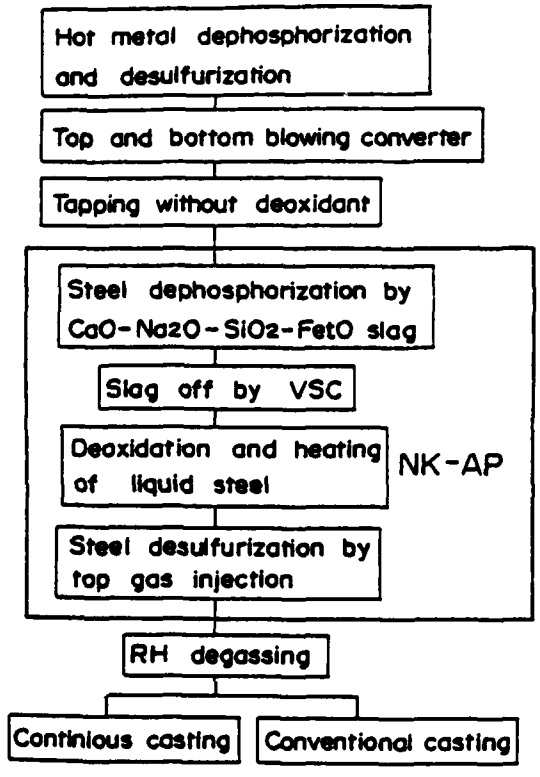


Figure 1. Production Flow Chart for the Fukuyama Works



Line Pipe for Sour Gas Service



9% Nickel Steel for Cryogenic Service

Figure 2. Two Examples of Processing Sequences for Production of Premium Quality Steels

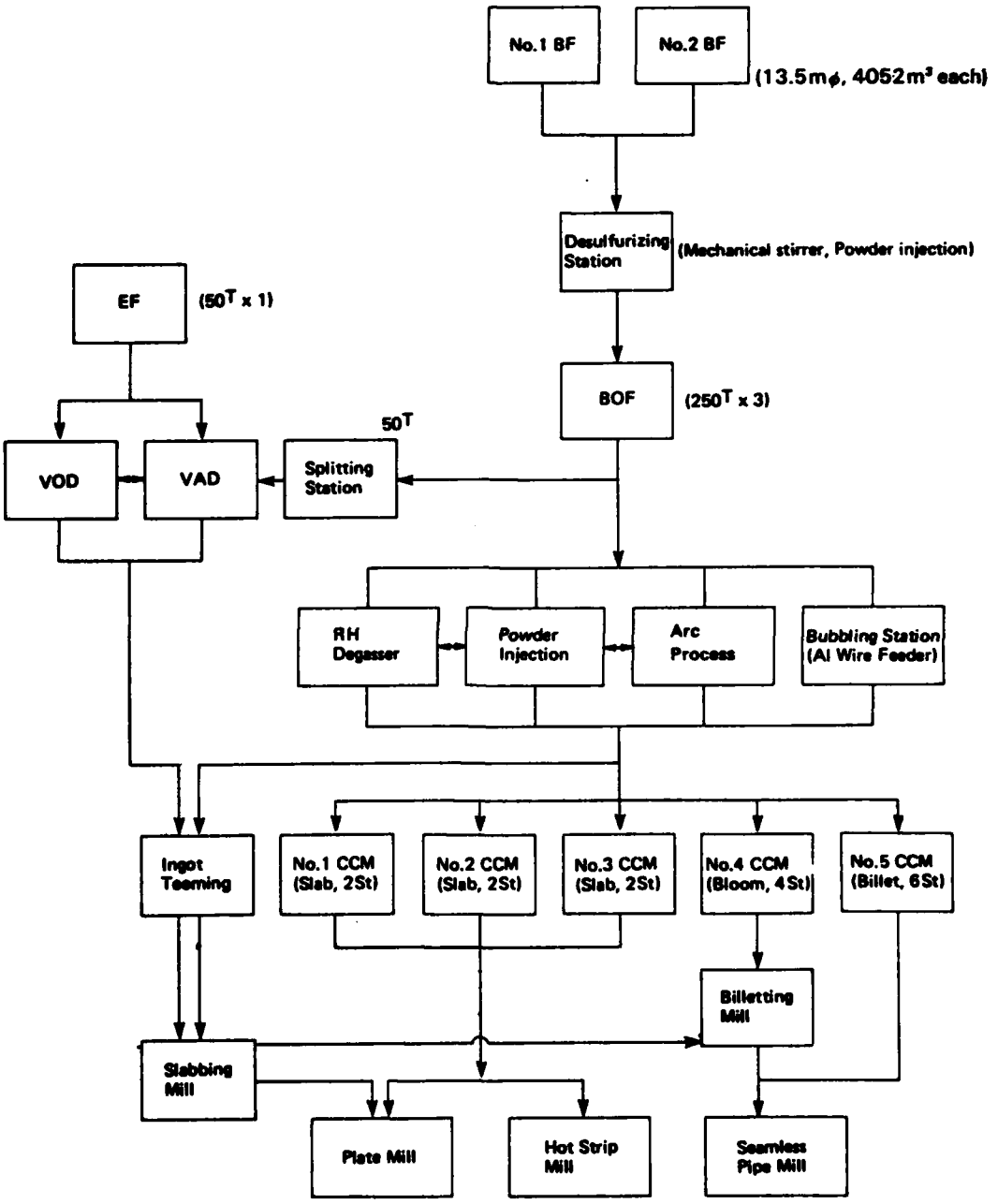


Figure 3. Production Flow Chart for the Keihin Works

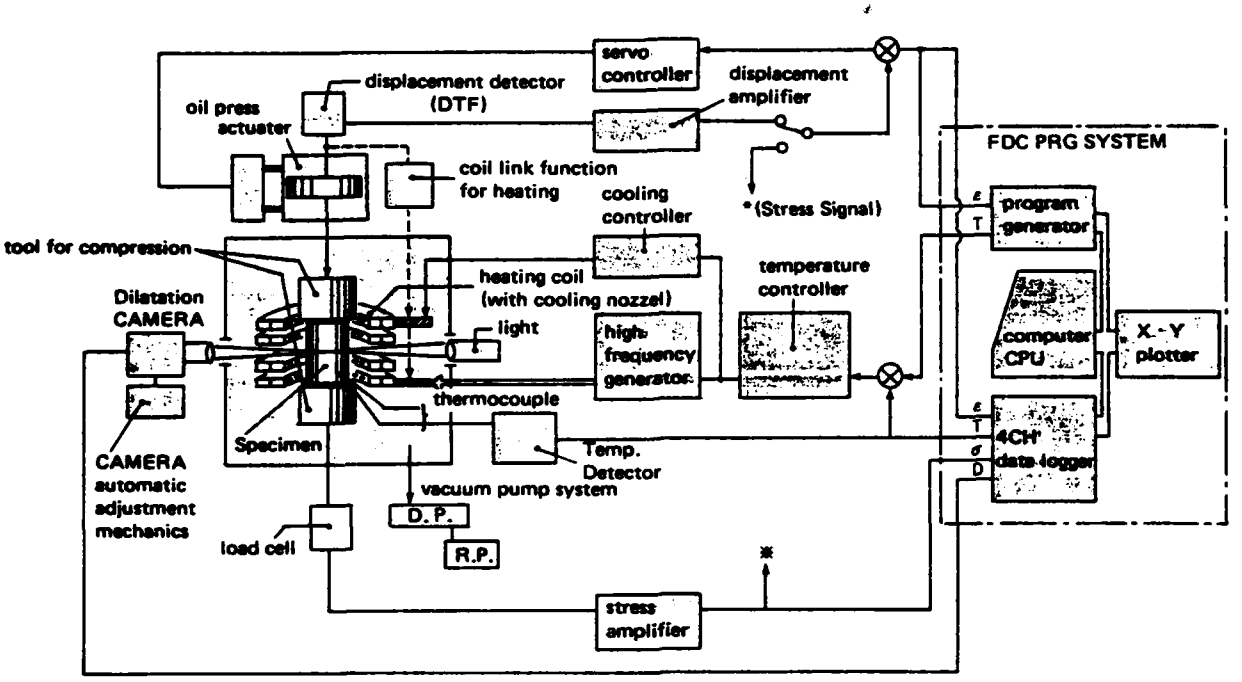


Figure 4. Block Diagram for Thermecmaster-Z

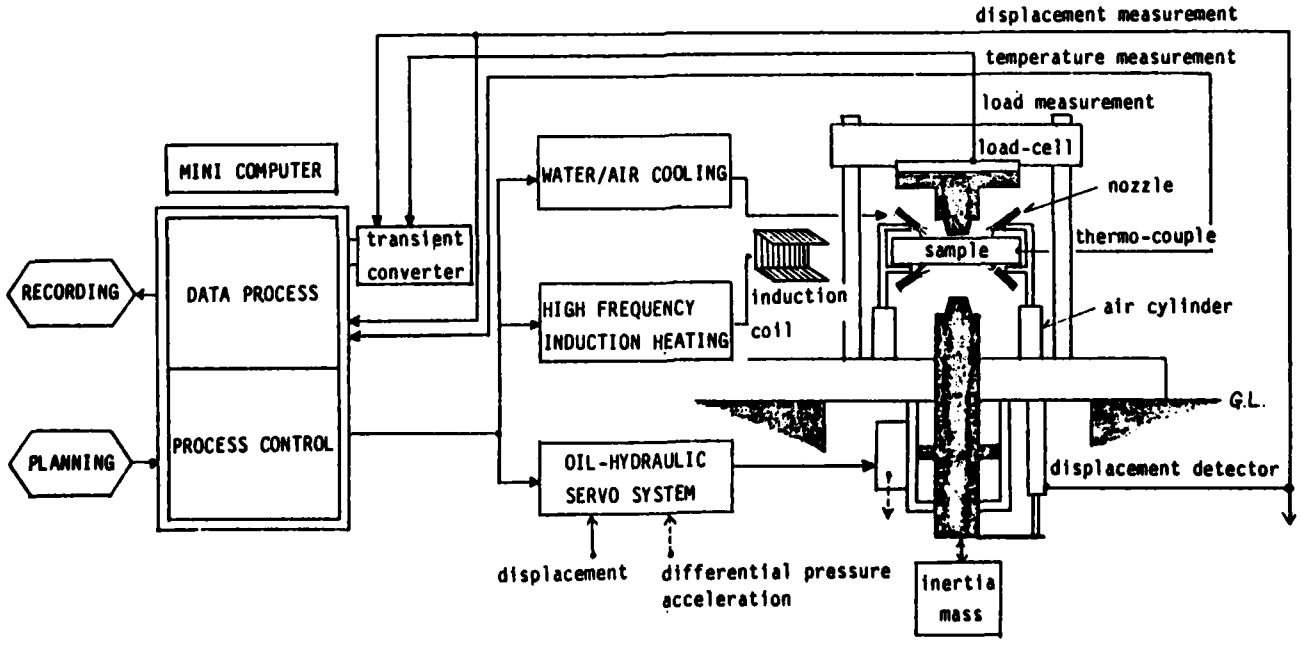


Figure 5. Block Diagram for the TMT Simulator

THE WORLD'S LARGEST STEEL COMPANY-VISITS TO NIPPON STEEL

Harry I. McHenry

Nippon Steel Corporation (NSC) is the largest steel company in the world with a production of 27 million tons in 1982. NSC has eight integrated steel works, including four with operating plate mills: Yawata, Oita, Kimitsu and Nagoya.

In this report, visits to the Yawata Works, the Oita Works, and Research Laboratories I and II are reviewed with emphasis on the technologies for producing and welding ship plate steels. During the plant tours, facilities and operations were observed for pretreatment of hot metal (pig iron), steelmaking in basic oxygen furnaces (BOF), ladle refining, continuous casting, and hot rolling. Technical discussions were focused on two subjects: production of clean (low impurity level) steels and weldability.

YAWATA WORKS

The Yawata Works are located in northern Kyushu, the island in western Japan. The Yawata Works, which started operations in 1901, was the first integrated steel works in Japan. Today, the works includes several production areas and has a crude steel output of 6 million tons. The original Yawata area contains various product mills, including the heavy plate mill. The Tobata area began operations in 1958. It contains the principal iron and steelmaking operations and several mills including the hot and cold strip mills. The Wakamatsu area is the main fabrication center for engineering and construction operations.

The production flow chart for steelmaking at the Yawata Works is shown in Figure 1. With three BOF steelmaking plants and a dozen or so product mills, the works is NSC's most versatile. Products include electrical steel, ferritic stainless steels, rails, seamless pipe, spiral pipe and a full range of flat rolled products. The discussion below is limited to the production facilities for ship plate and high strength steels.

- Hot Metal Treatment

Hot metal desulfurization is routinely employed in the production of plate products. The normal method is to top inject a CaO flux with some CaC_2 and CaF_2 into the hot metal within the torpedo car, the container used to transport the steel from the blast furnace to the steelmaking plant.

When low phosphorous is also required, treatments which simultaneously reduced S and P are used. In these cases, the silicon content of the hot metal must first be reduced from about 0.6% to less than 0.3%. This is done by adding mill scale (FeO) to the hot metal in the runner as it flows from the blast furnace to the torpedo car. The silicon is oxidized and enters the slag. Further reduction of silicon is accomplished in the torpedo car by adding more FeO. While covered with an oxidizing slag, a CaO(40%), Fe_2O_3(55%) and CaF_2(5%) flux is top injected into the hot metal to reduce phosphorous from 0.1% to less than 0.015% and sulfur from 0.04% to about 0.007%. This treatment takes about 20 minutes and results in a moderate temperature drop from about 1370°C to 1260°C. The treated metal is tapped into the charging ladle, the high phosphorous slag is solidified by adding sinter ore (Fe_2O_3), and the slag is skimmed off prior to charging.

To achieve even lower P and S levels, a soda ash (Na_2CO_3) injection treatment is performed in low silicon hot metal in the charging ladle. This treatment reduces the phosphorous content to less than 0.01% and the sulfur content to about 0.002%. However, soda ash treatment is hard on refractories and causes a large temperature drop to less than 1200°C. Thus, it is only used for special grades. As in the CaO treatment, the high phosphorous slag is removed prior to charging the BOF.

- Steelmaking

The basic oxygen process is used exclusively for steelmaking at the Yawata Works. The original plants have three 175-ton capacity BOFs and one 150-ton capacity BOF, respectively. The No. 3 plant, completed in 1979, has two 320-ton capacity units; one unit in production and the other in relining. The BOFs are equipped for bottom blowing with oxygen (~5% of total oxygen) to improve bath agitation. The 320-ton capacity BOFs can also be bottom blown with nitrogen, argon, or gas mixtures. Another feature of 320-ton BOFs is the use of CaO powder in the oxygen stream (top lance) to enhance dephosphorization. Some of the advanced steelmaking practices used in the 320-ton BOFs are being introduced into the No. 1 steelmaking plant.

Further dephosphorization can be achieved during tapping by adding a CaO flux with CaF_2 and Fe_2O_3. This flux, combined with the BOF slag, is oxidizing and must be skimmed off prior to ladle refining operations.

- Ladle Refining

The principal ladle refining technique used by the Yawata Works is vacuum degassing by the DH process. The No. 3 steel plant has a 320-ton capacity unit that treats 80-90% of the steel produced there. It features a vacuum vessel that fits within the ladle, thereby decreasing the energy required to suck the metal from the ladle into the vacuum vessel where degassing occurs. Injection of argon gas through the snorkel increases the surface area and accelerates degassing. Equipped with a high-speed lifting device (lifting cycle is 12 sec), the system can reduce hydrogen to less than 2 ppm and oxygen to less than 30 ppm in six-eight minutes.

The DH unit is also used for aluminum killing, removal of nonmetallic inclusions (mainly oxides), calcium treatment for sulfide inclusion shape control, and decarburization of low carbon products. Aluminum killing in the DH unit has two main advantages. First, the hydrogen removal rate is better while the steel is in the vigorous decarburizing condition prior to killing, thus the sequence of degas, aluminum kill, and cast is optimum. Second, deoxidation requirements are substantially reduced by degassing, and thus, a substantial savings in aluminum (about 1.3 kg/ton or 1000 lb Al/heat) can be achieved. Part of the savings in aluminum can be attributed to improved recovery and tighter tolerances on end-point aluminum. Calcium treatment is used for steels requiring especially low sulfur levels and sulfide shape control, e.g., seamless pipe for sour gas service. Currently, wire addition is used, but there are plans to add capability for Ca addition by top injection within the DH unit.

For the production of ultraclean steel, there is a 120-ton ladle furnace facility in Steelmaking Plant No. 1C. In this process the ladle has a porous plug in the bottom for argon bubbling, and it is tightly fitted with a furnace cover. The cover has a set of three-phase graphite electrodes, much the same as an electric furnace. Refining is accomplished by a basic slag and the slag-metal interaction is enhanced by argon gas bubbled through the bottom of the ladle.

The processing sequence for production of ultraclean steels starts with low temperature tapping of the BOF, and continues as follows: phosphorous reduction in the ladle using an oxidizing slag, mechanical skimming of the high phosphorous slag, addition of a basic reducing slag, fitting of the furnace cover over the ladle, submerged arc heating and ladle refining (reduced S and O), and finally RH degassing. Degassing is necessary because the ladle furnace does not reduce hydrogen or nitrogen content (it does protect against nitrogen pickup). This processing results in the following lower limits on impurity levels:

Sulfur	10 ppm
Oxygen	10 ppm
Nitrogen	20 ppm
Phosphorous	30 ppm
Hydrogen	2 ppm

In addition to impurity reduction, the ladle furnace/RH sequence permits better alloy recovery, removal of nonmetallic inclusions, homogenization of chemistry and temperature control. However, the ladle furnace treatment takes 60 minutes versus eight minutes for a light degassing treatment. Thus, it is only used for premium quality steels.

Ladle refining in the No. IN steelmaking plant is done by the vacuum slag refining (VSR) process. The VSR process is similar to the vacuum oxygen degassing (VOD) process commonly used for refining stainless steels. The same vacuum vessel, oxygen lance, and argon blowing facilities are used. An oxygen lance is used for heating, and argon is blown through a porous plug in the ladle bottom to provide stirring and reduce nitrogen content. A strong reducing slag and active stirring to promote slag metal reactions reduce sulfur to less than 0.001% . The No. IN plant is equipped with a DH degasser, but further degassing is not required after VSR treatment.

- Continuous Casting

Each of the steelmaking plants at Yawata are equipped with at least one continuous caster. The No. IC plant has an NSC four-strand bloom caster. The strand diameters are 215, 250, 290 and 325 mm. The No. IN plant has a Kobe (USSR) three-strand, vertical slab caster. Slab thicknesses are 200, 250, and 300 mm and width is adjustable between 800 and 1800 mm. The No. 3 plant has two Sumitomo (Concast) two-strand casters, one for slabs and the other for billets, blooms or, narrow slabs.

- Plate Mill

The plate mill is equipped with a two-high roughing mill with 4000-ton force and a four-high finishing mill with 6000-ton force. It is capable of producing plates up to 4.8 m wide. A hot leveler is used for plates up to 40 mm thick.

The line is equipped with an experimental facility for on-line accelerated cooling, referred to by NSC as the CLC (Continuous On-line Control) process. Production facilities for the CLC process are at the Kimitsu Works. The CLC facility at Yawata is 4.8 m wide by 15.5 m long. It is capable of handling plates up to 27 m in length because it is a continuous process. The plate passes through the hot leveler and then enters the CLC facility. There is a precooling zone in front with sprays at the top and bottom. The main part of the CLC unit has slit nozzles at the top which provide laminar water flow (water curtain), and roller quench nozzles on the bottom--16 headers each on the top and bottom. The CLC unit was not being used at the time of my visit.

OITA WORKS

The Oita Works is located on 7 million m^2 of reclaimed land on the eastern shore of Kyushu. It is NSC's newest integrated steelworks, starting operations in 1971 and fully operational in 1977. In terms of steel output per employee, the Oita Works may be the most efficient in the world. It has a crude steel output of 6 million tons and only 3700 employees. In contrast, the Yawata Works has similar output, but over 16,000 employees. The efficiency is due in part to a limited range of products, i.e. plate and hot-strip coils. But there are also many technical factors, including a simplified layout, large facilities, total continuous casting and directly coupled production processes, and computer control of all production and management operations.

The production flow chart for steelmaking at the Oita Works is shown in Figure 2. This is a remarkably simple chart because of the limited range of products. The operations of interest and the percentage of steel affected are as follows: hot metal desulfurization (60-90%), BOF steelmaking (100%), RH degassing (100%), continuous casting (100%), and hot rolling in the plate mill (20%). These operations are discussed in the following subsections. Blast furnace operations are not discussed, but it should be noted that blast furnace No. 2, with an inner volume of 5070 m^3, is the largest in the world.

- Hot Metal Treatment

Hot metal is transported from the blast furnace to the steelmaking shop in 600-ton capacity torpedo cars. The first stop is the desulfurization station, adjacent to the steelmaking plant. Here, CaO or CaC_2 flux is powder-injected within the torpedo car. The sulfur level is reduced from 0.03% to an average of 0.012%. Treatment time is 10 minutes. A system for hot metal dephosphorization with lime will be installed in 1984.

- BOF Steelmaking

The Oita Works has three 340-ton BOFs, each equipped for bottom blowing with oxygen (less than 10% of total) to improve stirring. Steelmaking efficiency is optimized by minimizing the variations in the input and output conditions. All heats are blown to an end point carbon of 0.1%. Chemistry adjustment is accomplished in the RH degasser. Constant end point carbon tends to improve the BOF yield, increase the residual manganese (to 0.25%), stabilize the end point phosphorous (at 0.015%), reduce the reblow ratio, and extend refractory life.

- Ladle Refining

The RH degassing process is the only ladle refining technique used at the Oita Works. However, several secondary refining functions are performed in the RH vessel. The basic idea is that the RH vessel is a vacuum processing unit with vigorous stirring. These characteristics are effectively used to perform the following functions over and above degassing:

- inclusion removal,
- alloy addition and homogenization of composition,
- temperature adjustment prior to casting,
- aluminum killing.

Alloy addition within the vacuum vessel increases recovery and aluminum killing after reducing the oxygen content decreases aluminum consumption. However, the main purposes of the RH cycle are to provide the chemistry adjustments necessary for constant end-point operation of the BOF, and to prepare the steel for continuous casting, i.e., temperature adjustment, degassing, and aluminum killing. An RH light treatment has been developed to perform these functions within a minimum cycle time.

Occasionally, it is necessary to increase the temperature during the RH cycle. An aluminum reheating method is used at Oita. By adding 1 kg of aluminum per ton of steel, it is possible to increase the steel temperature by 30°C. An equivalent amount of oxygen is blown into the vacuum vessel to react with the aluminum. This treatment is not normally required because temperature drop due to RH processing has been reduced to 10°C by use of vessel preheating and minimum cycle time.

Research work is in progress to develop a means of flux addition to the RH vessel to improve ladle refining capabilities. Also, various means of increasing the circulation speed are under consideration. One such method is argon injection into both the upper and lower parts of the suction tube. This method is currently being used at other NSC works to increase the rate of decarburization.

- Continuous Casting

The Oita Works uses continuous casting for essentially 100% of production. It has four two-strand continuous casting machines of the Mannesmann curved type. Two of the units produce slabs of various sizes; thicknesses range from 200-300 mm, and widths of 900 to 2200 mm. The other two units produce single size (280 mm x 1800 mm) slabs of variable length that subsequently go to a sizing mill which is used to adjust the width and thickness. The sizing mill has the conventional horizontal rolls for thickness reduction, plus vertical axis rolls for width reduction.

The continuous casters have a ladle turret for the 340 tons of steel from one BOF heat. The steel is tapped through a sealed nozzle between the ladle and tundish. The 65-ton capacity tundish has a sliding nozzle for mold level control and sealed nozzles feeding the mold. Two of the casters have electromagnetic stirring during the final stages of solidification. Slab cracking is reduced by use of a compression casting technique, whereby drive roll speeds are adjusted to induce compressive stresses at the tangent point where the slab becomes level.

- Plate Rolling

The continuously cast slabs go directly to the slabbing plant where most of them are reheated and subjected to width adjustment by the sizing mill. The slabs are then transferred to either the hot strip mill (80%) or the plate mill (20%), and hot charged into continuous reheating furnaces. In the plate mill, the slab goes through a walking-beam reheating furnace, a high-pressure-water scale breaker, and then enters the finishing mill. The plate mill is a four-high reversing mill with automatic gage control and capacity to produce plates up to 5.3 m wide and 36 tons in weight. The plate then passes through a hot leveler and enters the cooling bed. The CLC process, which involves controlled cooling, is not used at the Oita Works.

RESEARCH LABORATORIES

Research and development are conducted by three central laboratories and laboratories at each of the nine steel works. Total employment exceeds 2200 persons. The central R&D bureau was recently (June 1983) reorganized to integrate the activities of the three central laboratories. Formerly, there were the Fundamental Laboratories in Kawasaki (near Tokyo), the Products R&D Laboratories in Sagamihara (near Tokyo), and the Process Technology R&D Laboratories in Kitakyushu (near Yawata); these have been renamed R&D Laboratories I, II, and III, respectively. The reorganization integrated research activities into four themes:

- steelmaking,
- diversification,
- basic technologies,
- basic research.

Research on steelmaking technologies has eight laboratories for steelmaking processes and products, five at Laboratory II and three at Laboratory III. Research related to diversification has four laboratories for new materials at Laboratory I and one for energy technology at Laboratory III. Research on basic or peripheral technologies has laboratories for welding (Lab II), forming (Lab III), instrumentation (Lab I), analysis (Lab I), and heat technology (Lab III). Basic research has three laboratories (all at Lab I) for theoretical and advanced studies in physical metallurgy, process metallurgy, and surface science. The allocation of the professional research staff among these themes is shown in Table I.

The principal topics of discussion regarding NSC research were related to welding of steel structures. Topics included:

- weldability of steel,
- welding consummables,
- welding equipment,
- fracture testing of steel weldments.

Most of these discussions and related laboratory tours took place at R&D Laboratories II, where I visited on three occasions. I had an extended discussion at NSC headquarters with Dr. Haruyoshi Suzuki, Executive Advisor for Welding, regarding the significance of the weldability research. In addition, I also had the opportunity to visit R&D Laboratories I and see many of their outstanding analytical facilities.

- Weldability

The weldability of steels for large structures such as ships and offshore structures is a continuing area of research at Nippon Steel. The status of this work as of 1982 was summarized by Dr. Suzuki in the Houdremont Lecture to the International Institute of Welding (IIW) [*Trans. ISIJ*, 189 (1983)]. This report reviews recent progress in steel plate manufacturing technology and its relation to weldability. The key aspects of weldability are susceptibility to cold cracking and heat affected zone toughness.

Cold cracking susceptibility is an important measure of weldability because the remedial actions taken to prevent cold cracking reduce the efficiency of welding, i.e., preheating and heat input controls. The susceptibility of steels to cold cracking has been

extensively studied by Dr. N. Yurioka and co-workers of R&D Laboratory II and Dr. Suzuki of the NSC headquarters. Dr. Yurioka coauthored a series of eight papers to the Japan Welding Society. These reports are in Japanese, but an excellent summary paper has been published in English: "Determination of Necessary Preheating Temperature in Steel Welding" [*Welding Journal*, 147-s (1983)]. In addition, Dr. Suzuki has prepared a series of reports to the IIW.

In the *Welding Journal* paper, a new formula for calculating carbon equivalent is proposed and shown to be superior to the IIW and Pcm approaches. Furthermore, a step-by-step procedure for determining preheat is presented. The procedure uses a cracking index to account for base metal susceptibility (carbon equivalent), hydrogen concentration (weld metal hydrogen measured by the JIS glycerin displacement method), and mechanical constraint (Japan Steel Structure Construction, JSSC method).

The cracking index is empirically related to the critical weld-cooling time to 100°C, i.e., shorter times cause weld cracking. A series of parametric plots are used to show cooling time as a function of preheat temperature where the parametric variables are plate thickness, heat input, and preheating technique. In summary, a preheat temperature is selected such that the cooling time is sufficiently slow to avoid cracking under the conditions given by the cracking index.

Yurioka and co-workers have also developed a formula for relating the maximum hardness in the heat affected zone to chemical composition and cooling time between 800° and 500°C. This formula is useful for selecting steels and welding procedures that meet specified limits on HAZ hardness. Note that HAZ hardness depends on cooling time between 800° and 500°C, whereas cracking susceptibility depends on cooling time from the moment of welding to 100°C. This is because hydrogen is most deleterious below 100°C.

- Welding Consummables

Toughness improvements due to microalloying weld metal with titanium and boron were first reported by Dr. Suzuki of NSC in the early 1970s (IIW documents II-583-71, and IX-750-72). This was attributed to grain refinement and suppression of proeutectoid ferrite formation along austenite grain boundaries. Recent studies have led to an understanding of the mechanism of toughness improvement in Ti-B bearing weld metals. The role of titanium is to promote intragranular nucleation of fine acicular ferrite. Nucleation sites within the grains are finely dispersed titanium oxides, i.e., TiO and to a lesser extent, Ti_2O_3. TiO is an effective nucleation site for ferrite because the lattice disregistry of TiO, a NaCl-type cubic phase, is only 3% with α-iron. Titanium also serves to protect the boron from oxygen and nitrogen. Thus, free boron can migrate to the austenite grain boundaries where it retards nucleation of proeutectoid ferrite. Finally, both boron and titanium form nitrides and thus the soluable nitrogen, which lowers ferrite toughness, is reduced.

Understanding of the mechanism of toughness improvement in Ti-B weld methods has contributed to the development of new fluxes for submerged arc welding steels for low temperature service [*Weld. J.*, 373-s (1982)]. The new fluxes are fused-type and contain TiO_2 and B_2O_3, which decompose in the welding arc and add Ti and B to the weld metal. The fused-flux approach was found to provide consistent levels of Ti and B near the optimum contents over a wide range of heat inputs. However, as heat input is increased, more proeutectic ferrite forms at the austenite grain boundaries and toughness is reduced. To maintain toughness, wires with 2% Mn and 0.25% Mo are used to suppress

proeutectoid ferrite formation (IIW Documents XII-A-32-82 and XII-E-27-82, 1982). The resulting welds are suitable for service to at temperatures of -40°C to -60°C.

- Welding Equipment

The largest single group at the R&D laboratories is the Welding Technology Laboratory with about 140 members. About 100 of these are employees of the NSC subsidiary, Nippon Steel Welding Products and Engineering Company. I toured one of the welding technology laboratories and saw demonstrations of narrow gap welding, reduced heat-input electrogas welding, separated electrode submerged arc welding, and 2-D arc oscillations for gas metal arc welding.

Nippon Steel has developed procedures and consummables for narrow gap welding by the submerged arc and gas metal arc processes. For submerged arc welding, the key development is a flux with excellent slag removability. Conventional submerged arc equipment is used along with a wire guide to keep the wire centered for "one-run-per-layer" welding. For narrow gap welding by the gas metal arc process, NSC has developed the LOOPNAP process in which arc oscillation is achieved by a special mechanical device which oscillates the wire while the torch remains fixed in the groove. As shown in Figure 3, the wire is first bent over a small diameter (40 mm) roll and then passes around a larger diameter (70 mm) roll, called the loop panel, and finally through a fixed guide tube to the tip of the torch. The loop panel is oscillated and this mechanical oscillation is transferred to the tip end of the wire causing the arc oscillation necessary to achieve a sound single layer weld. The amplitude of arc oscillation can be varied from 9 to 15 mm by adjusting the panel oscillation and wire extension.

For vertical welding, the electrogas welding process has been modified to permit use of lower heat inputs (less than 100 kJ/cm). The modified process, called vibratory electrogas welding (VEGA), is shown schematically in Figure 4. The key modifications are use of small diameter flux-cored wire and CO_2 shielding gas, through-the-thickness oscillation of the torch, and use of a beveled groove (28 to 45° included angle). Weld shape is controlled by a fixed copper shoe at the weld root and a sliding, water-cooled, copper shoe at the face.

Another vertical welding process is automatic gas-metal arc welding with an oscillator that has vertical and horizontal components, referred to as OSCON. Proper adjustment of electrode motion, including dwell times, permits use of higher currents and reduces the incidence of lack-of-fusion defects. Variations of the process and matching consummables are available for vertical butts and fillets, curved joints, and flat position welding.

Nippon Steel has recently developed a modification to the multiple electrode submerged arc welding process that effectively lowers the heat input while maintaining a high deposition rate. This has been accomplished by separating the lead and trailing electrodes by distances up to 1 meter. The idea is that the lead electrode deposits a weld that solidifies and cools below the transformation temperature before the trailing electrodes add to this deposit. The problem that had to be overcome was arc stability in the trailing electrodes. Stability was provided by spacing the two trailing electrodes sufficiently close (10 mm or less) so that an arc was maintained between the electrodes. In addition, metal powder was added to the flux to increase the conductivity of the slag. With this process, it is possible to weld thicknesses up to 32 mm in one or two passes and meet Charpy toughness requirements at -60°C.

- Weldment Evaluation

Nippon Steel uses a variety of large-scale fracture tests to evaluate the crack initiation and dynamic crack arrest characteristics of welded structures. The purpose of large tests is to properly simulate the residual stresses due to welding and the mechanical constraint of full-thickness joints. The latest development in crack-arrest testing is the short-crack-arrest test. As shown in Figure 5, a crack starter plate is welded to a test plate. The test plate is loaded in tension, and then a crack is initiated in the starter plate with enough driving force to enter the test plate. The crack either arrests in the test plate (successful performance) or propagates. Results are reported in terms of stress level versus temperature for crack arrest. Starter plates can be located to evaluate the crack arrest characteristics of the base metal, the weld or the heat affected zone.

Small specimens are also tested to evaluate the fracture behavior of welds. A new test method has recently been developed to evaluate the fracture toughness in the heat affected zone. The test, referred to as the fatigue COD test, uses a fatigue precracked notch-bend specimen of the type standardized for fracture toughness testing according to the crack opening displacement (COD) method. The method, described in Figure 6, is to locate a precrack in the weld above the HAZ and then to propagate the crack through the HAZ under constant amplitude fatigue cycling. If the specimen fails when the crack enters the HAZ, the brittle zone is identified, and the fracture toughness can be calculated. If failure does not occur, load is increased in the next test and the procedure is repeated. In this way, the various metallurgical regions within the HAZ are interrogated and the minimum toughness is established. With conventional procedures, the fatigue precrack is randomly located within the HAZ, and there is a large scatter in the test results.

The mechanical testing laboratory at the R&D Laboratories II is well equipped for a wide variety of fracture tests. Notable facilities include two large test machines for wide plate testing, one with an 8000-ton force capacity and the other with 2000-tons. Current projects for these machines include tests on 9% nickel steel for cryogenic storage tanks, structural plate weldments for arctic service, and tubular joints for offshore structures.

SUMMARY COMMENTS

Nippon Steel has its roots in the government-operated Yawata Works founded in 1901 and the semigovernmental company, Japan Iron and Steel Company, Ltd., founded in 1934. After the war, the Japan Iron and Steel Company was split into private companies, principally the Yawata Iron and Steel Company and the Fuji Iron and Steel Company. These companies grew during the postwar period, and in 1970 merged to form the Nippon Steel Corporation. This corporation, with its roots as a governmental enterprise, has retained a sense of duty and service to Japan. Now, it is an integral part of the industrial machine known as "Japan, Inc."

When one visits Nippon Steel, the size and efficiency of the facilities are the dominant impression. For example, at the Oita Works, one seeks the world's largest blast furnace, the 340-ton BOFs, the 5.3-m-wide plates and the 45-ton coils. But, beyond these internal strengths, NSC makes important contributions to Japan's industrial base. Many shipyards are conducting joint research with NSC and other companies to develop improved steel structures for the Arctic region. Osaka Gas, a large user of liquified natural gas, teamed up with NSC and others to verify the structural safety of 9% nickel

steel for storage tanks. The Japan Atomic Energy Research Institute has proposed a set of requirements on steels for superconducting magnets needed for fusion energy projects; NSC has developed a new stainless steel (25 Cr-13 Ni-1 Mo) with a yield strength in excess of 1200 MPa (175 ksi) at 4 K in response to this proposal. The visits to R&D Laboratories II, discussed in this report, also exemplify the contribution of NSC to Japan's industrial base. Welding is a generic technology, and the advances in productivity resulting from welding research are used by many segments of industry. In short, one gets the impression: "What's good for Japan is good for Nippon Steel."

ACKNOWLEDGEMENTS

Many employees of Nippon Steel kindly provided me with detailed descriptions of their steelmaking practices and their research programs. I greatly appreciate the generosity, patience, and competence of those listed below. I am particularly indebted to Mr. Mikifumi Katakami of the Technical Administration Bureau, who arranged most of the visits and served as my principal contact with NSC. I also appreciate the contributions made by Professor Susumu Machida of Tokyo University, who accompanied me on one visit to R&D Laboratory II and Professor Thomas W. Eagar of MIT, who accompanied me on a second visit.

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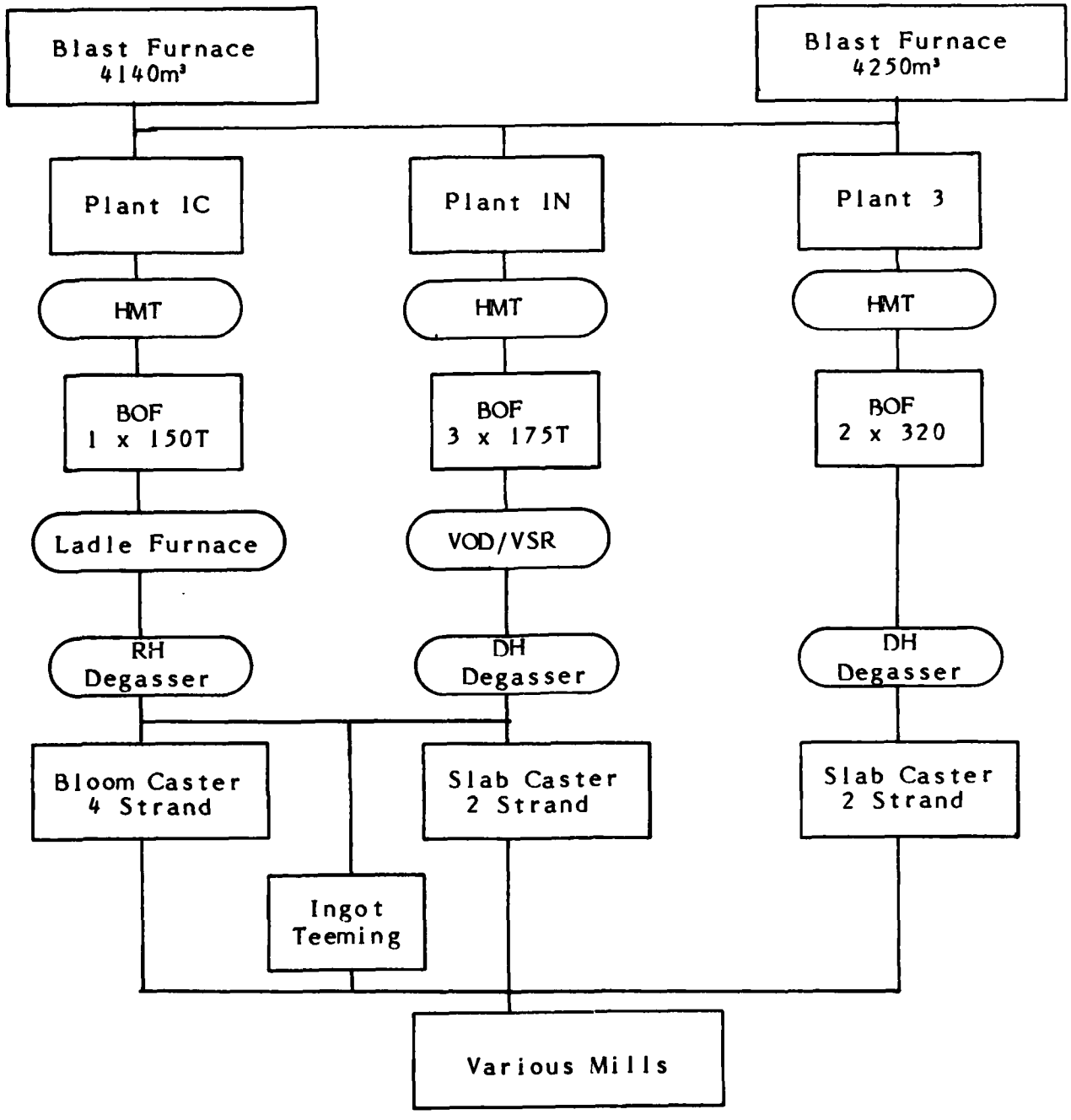

HMT - Hot Metal Treatment
VOD - Vacuum Oxygen Degassing
VSR - Vacuum Slag Refining

Figure 1. Production Flow Chart for the Yawata Works (oval boxes indicate optional treatments)

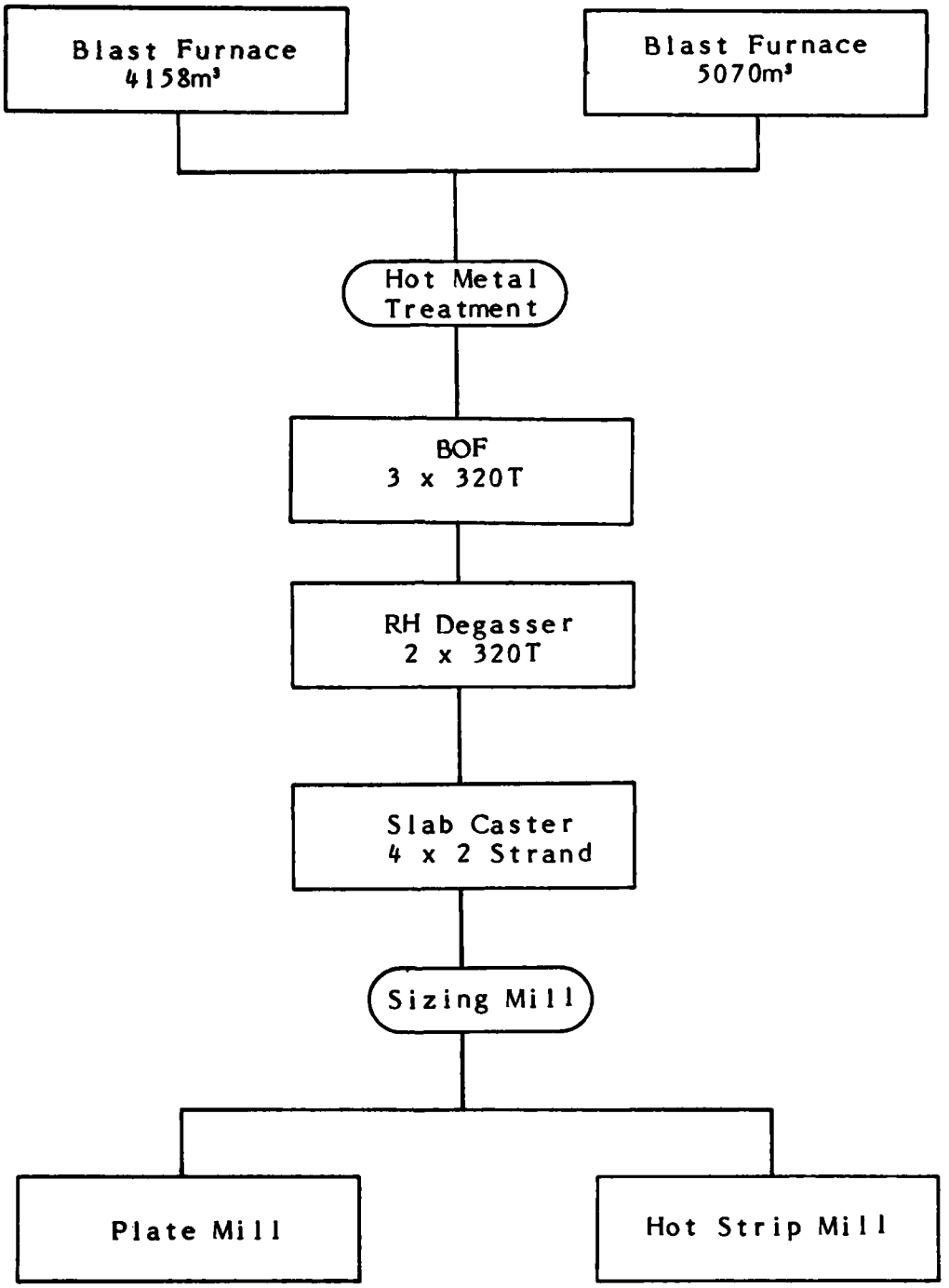

Figure 2. Production Flow Chart for the Oita Works (oval boxes indicate optional treatments)

TABLE I

DISTRIBUTION OF THE PROFESSIONAL STAFF AT NSC LABORATORIES

Laboratory	Researchers	Theme	Researchers
R&D Labs I	147	Steelmaking	245
II	204	Diversification	72
III	124	Technologies	134
		Basic Research	24
Works Labs	324		

THE OKAZAKI NATIONAL RESEARCH INSTITUTES

P. F. Iampietro

INTRODUCTION

The Okazaki National Research Institutes (ONRI) was established in April 1981 and consists of three institutes which formerly had been independently managed. The Institute for Basic Biology and the Institute for Physiological Sciences were part of the National Center for Biological Sciences which was established in May 1977. The third entity, the Institute for Molecular Science, was added at the time the ONRI was established. The National Center for Biological Sciences was disestablished at that time. The institutes are managed independently, have individual objectives but share some facilities, and are under the general guidance of the President and Council of ONRI.

The ONRI is located on a hill in Okazaki (near Nagoya) overlooking the city and the Otogawa River. The laboratories and other buildings are all of recent construction, attractive and spacious. Scientists at the institutes have adequate laboratory space and are well-equipped. For example, the two institutes I visited (Biology and Physiology) have access to a total of nine electron microscopes (scanning and transmission) including a high voltage (1250 kV) microscope housed in a separate building and used primarily for stereoscopic work.

The institutes are considered to be interuniversity institutions with their own intramural research programs as well as cooperative programs with various universities throughout Japan. In essence, the programs fall into the following groupings:

- joint research programs in which university scientists participate in research with institute scientists,
- facility-sharing programs in which institute resources are utilized by university scientists,
- graduate student programs in which graduate students perform research at the institutes under the guidance of institute scientists.

In addition, there are international programs in which foreign scientists conduct their own research at the institutes. The institutes have two lodges available to accommodate visiting scientists and families from Japan and abroad. Exchange programs are encouraged and several foreign scientists were in residence during my visits, including Dr. C. Woody, a leading neurophysiologist from the University of California, Los Angeles (UCLA). Research fellows are sponsored by the Japan Society for the Promotion of Science (JSPS) and the Ministry of Education, Science, and Culture (Mombusho). Although the institutes do not have graduate students, they are authorized to accept students from graduate schools of Japanese universities.

ORGANIZATION OF INSTITUTES

Each institute has a director-general who oversees the operation of the institute. He is assisted in this task by two advisory bodies. One group is advisory for policy and operations and the other for programs and scientific activities. The latter group consists of an equal number of university professors of science and institute professors, while the former group consists of distinguished scholars from all academic fields. An administrative bureau performs all of the financial and general affairs activities for each institute.

The research for each institute is performed within departments composed of laboratories or divisions. The departments in the Institute of Physiological Sciences have no head and are associations of groups performing research which can be conveniently grouped together. The departments in the Institute of Basic Biology have chairmen. The departments and laboratories/divisions and facilities are shown in Appendixes I-III. Each laboratory/division consists of a professor, associate professor, one or two research associates and sometimes one or two technicians.

All institutes have adjunct positions which allow the institutes to have larger staff without going over the staffing ceilings set for them. Adjunct laboratories are currently provided in all departments and some very widely known and respected scientists from Japanese universities hold adjunct professorships at Okazaki. The adjunct professors for biology and physiology are shown in Appendix I and II. Adjunct professors spend the summer months at Okazaki plus short periods of time whenever possible during the academic year. Each adjunct laboratory does have one or two research associates at Okazaki year-round who conduct the activities of the laboratory while the professor is away.

RESEARCH PROGRAMS

A brief description of the research activities of each laboratory/division is given here which may be useful to the reader in determining the scope of the research programs at ONRI. Most, but not all, the departments were visited by the writer. A later report will consider in more detail the membrane and synapse research being conducted here and elsewhere in Japan.

INSTITUTE OF BASIC BIOLOGY

- Department of Cell Biology

This department, as the title states, is concerned with basic functions of the cell. Its five divisions conduct research on all aspects of cell structure and function at the molecular level.

- Division of Cell Mechanisms

The research program of this division is primarily concerned with the mechanisms of mitochondrial proliferation and cytoplasmic streaming at the molecular level using a multinucleate slime mold. Physiological, morphological, and biochemical approaches are used. Mitochondria and mitochondrial nuclei are intensively studied.

- Division of Biological Energy Conversion

Photosynthesis in blue-green algae is the process studied to determine the mechanism of conversion of energy--in this case light energy to metabolic energy. Molecular architecture of the photosynthetic elements and of the photosynthetic reaction center are areas of primary effort. Electron flow dynamics are investigated.

- Division of Cell Fusion

Biology and genetics of cultured mammalian cells are studied utilizing cell engineering techniques based on cell fusion phenomena.

- Division of Cellular Communication

This division attempts to elucidate transfer of information across cells through study of extracellular messengers and cell surface receptors. The molecular basis for hormone action in cell communication is currently being studied and a new receptor function may have been uncovered which seems to be directly coupled to phosphatidylinositol turnover. Calcium and diglyceride activate a protein kinase which plays a role in control of a wide variety of cellular activities through protein phosphorylation.

- Department of Developmental Biology

The department has two active divisions, another which is currently being staffed and a fourth which is yet to be activated. The research of the department centers around cellular and molecular mechanisms of the processes which control development.

- Division of Reproductive Biology

Oocyte maturation in the starfish has been studied extensively. Several mediators (gonad-stimulating substance, maturation-inducing substance, maturation-promoting factor) involved in various stages of the maturation process are the objectives of the research. Isolation, characterization, biosynthesis and function of the various substances are being investigated. Other species of marine animals are under investigation (teleosts).

- Division of Cell Differentiation

The research program places special emphasis on the regulatory mechanisms of tissue-specific genes during cellular differentiation. Both *in vitro* and *in vivo* studies are conducted. Isolation of target wild type genes and preparation of desired mutant genes from the wild types (*in vitro*) and tests of biological functions of the wild type and mutant genes (*in vivo*) are done.

- Department of Biological Regulation

The research of this department is primarily concerned with information processing and control mechanisms in biological systems.

- Division of Sensory Processing

The major activities of this laboratory center around the morphology of the catfish retina with attention to functional aspects and identification of spatiotemporal filtering characteristics. It is of interest that this work was started in the United States and continued after the investigator returned to the institute. The laboratory intends to apply the same techniques to a study of the functional morphology of developing retinas.

- Division of Chronobiology

Biorhythms of neurospora and duckweed are studied. In the former, the genetic and biochemical characteristics of the clock which controls conidiation (formation of small asexual spores) rhythm, and in the latter, the physiological and biochemical effects of the clock which regulates potassium uptake rhythm are investigated.

- Division of Biological Regulation

The physical and chemical charateristics of phytochomes (which mediate plant development) are studied. Two other areas of study are (1), the action of photoreceptors which regulate function of biological membranes, and (2) identification of light-absorbing pigments that control several photobiological processes, phototaxis, and others.

- Division of Behavior and Neurobiology

Invertebrate behavior is studied utilizing electrophysiological, morphological, behavioral, and genetic analysis. Neuronal mechanisms of the fly visual system is studied as well as the molecular mechanisms of taste and feeding behavior in the fruit fly (through study of mutants). Righting behavior and locomotion in the cricket and the neuronal control are studied.

INSTITUTE FOR PHYSIOLOGICAL SCIENCES

- Department of Molecular Physiology

Work in this department is concerned with the elucidation of physiological functions at the molecular level. The department consists of three laboratories.

.Laboratory of Ultrastructure Research

The techniques [primarily, nuclear magnetic resonance-(NMR)] used by this laboratory provide the means to study dynamic changes of cells and cell structures. Metabolic activities of several enzymes are studied in relation to their structures as revealed by NMR. Flavoenzymes and a new oxidation-reduction enzyme, quasi-D-amino acid oxidase are being investigated.

.Laboratory of Cellular Metabolism

Immunochemical, biochemical, physiological, and synthesis studies are performed in this laboratory with the purpose of elucidating the synthesis, release, regulation, distribution, metabolism, and receptor binding of brain-gut peptides. In most studies, the research crosses over two or more of the above areas. Some specific investigations are concerned with regulation of peptide hormone release from neuroendocrine cells; study of receptor binding of neuropeptides to membrane fractions of a neuronal cell line; and studies of the cellular origin and distribution of peptides in mammalian tissue using region-specific antisera against synthetic peptides.

- Department of Cell Physiology

The three laboratories in this department conduct studies of cell and organ function with the primary aim of defining the mechanisms of excitation, inhibition, conduction, and transport of ions across membranes.

.Laboratory of Membrane Biology

The giant squid axon is the primary biological tissue used. Factors affecting the neuronal excitation process are investigated including the effects of divalent ions (intracellularly) on membrane excitation and the effects of high osmotic pressure and

low temperature of surrounding fluids on the characteristics of excitable membranes. A second area of research explores the development of acetylcholine receptors in cultured skeletal muscle cells. The research program of this, and other laboratories will be described in more detail in a later report.

.Laboratory of Correlative Physiology

The research of this laboratory, in part, is similar to the research in the Laboratory of Membrane Biology. The intracellular composition of squid giant axon was altered by injection of solution and the resultant changes in membrane potential and electrical conductance were assessed. Results are explained in terms of function of ionic channels. Additional work is concerned with changes in nerve fiber conformational characteristics during excitation.

.Laboratory of Active Transport

This laboratory is concerned with the active transport of materials (nutrients) into the cell and out of the cell (waste products) against concentration gradients. Recent work is concerned with Na, K-ATPase in membrane fractions.

- Department of Information Physiology

This department has four laboratories, but only two were fully staffed and operational at the time of my visit. The department program is heavily oriented toward the physiology of vision.

.Laboratory of Neural Information

This is the largest and most active of the laboratories in the department. The research investigates the neuronal processing of visual information in the retina. Structure and function of each type of cone is studied via microelectrodes and electron microscope (HRP-filled cells). Synaptic structures were determined. The dendritic connections of horizontal cells to photoreceptors were studied under the light microscope and physiological studies of the connections were also done. The research has revealed that the outer retinal layer, where photoreceptors have synapses with second-order neurons, plays an important part in processing of visual information.

A small international workshop was convened under the sponsorship of this laboratory during the fall of 1983. The title of the workshop was "Visual Information Processing--From Photoreception to Memory" and was attended by invited speakers from Japan (seven), United States (three) and Great Britain (one). I attended the workshop and was impressed with the content and the caliber of the participants. The laboratory is able to attract such participants because of the quality of the research being conducted here and the reputation of the director.

.Laboratory of Humoral Information Research
.Laboratory of Learning and Memory Research

These two laboratories have only recently been staffed and equipped and the research is still in an early stage. The first laboratory will investigate the regulation of synapses and the second the mechanisms of learning and memory.

.Laboratory of Higher Nervous System

This laboratory is the only one to use brain slices in its research. The electron microscope is utilized to study plasticity and morphometric characteristics of nerve cells using a computerized image analyzer. Brain stem slices are used for other neuronal function studies.

- Department of Biological Control Systems

Two of the three laboratories in this department have been activated. Research considers neural aspects of regulation and information processing which is under neural control.

.Laboratory of Neural Control

The characteristics of cardiac excitable membranes are being studied by means of analysis of ionic membrane current in both sinus node cells and atrioventricular node cells. Single cell isolation techniques are used.

.Laboratory of Humoral Control

Activity patterns of neurones in the prefrontal area (Rhesus monkeys-chronic preparation) were studied as a function of food intake using multibarrelled microelectrodes. The mechanisms by which the central system integrates input information and the chemical regulatory mechanisms involved in influencing food intake are being investigated.

SUMMARY

In my opinion, the ONRI is a very high quality research institute. Many of the top personnel have international reputations and are well-published in English language journals. The facilities and equipment are first-rate. The research areas receiving the most attention are those which are being vigorously pursued in the United States and which hold promise of providing important fundamental knowledge on the mechanisms by which excitable tisues function.

For further information inquiries may be directed to:

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(Tele) 0564-52-9770

or

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APPENDIX I

INSTITUTE FOR PHYSIOLOGICAL SCIENCES

DEPARTMENT	LABORATORY	HEAD
Molecular Physiology		
	Ultrastructure Research	Professor H. Watari
	Cellular Metabolism	Professor H. Yanaihara*
	Neurochemistry	To be established.
Cell Physiology		
	Membrane Biology	Professor S. Yamagishi
	Correlative Physiology	Professor A. Watanabe
	Active Transport	Professor M. Nakao*
Information Physiology		
	Neural Information	Professor A. Kaneko
	Higher Nervous System	Professor H. Tsukahara*
	Humoral Information Research	Professor K. Hama
	Learning and Memory Research	Professor M. Kuno*
Biological Control System		
	Neural Control	Professor H. Irisawa
	Humoral Control	Professor Y. Oomura*
	Biomedical Engineering	To be established.

*Adjunct

APPENDIX II

INSTITUTE FOR BASIC BIOLOGY

DEPARTMENT	DIVISION	HEAD
Cell Biology		Professor Y. Fujita
	Cell Mechanisms	Professor T. Kuroiwa
	Biological Energy Conversion	Professor Y. Fujita
	Cell Fusion	Professor Y. Okada
	Cellular Communication	Professor Y. Nishizuka
	Cell Proliferation	Professor Y. Hiramoto*

Developmental Biology		Professor G. Eguchi
	Reproductive Biology	Professor H. Kanatani
	Cell Differentiation	Professor Y. Suzuki
	Morphogenesis	Professor G. Eguchi
Biological Regulation		Professor Y. Fujita
	Sensory Processing	Professor K. Naka
	Chronobiology	Professor Y. Oota
	Biological Regulation	Professor M. Furuya*
	Behavior and Neurobiology	Professor K. Mimura

*Adjunct

APPENDIX III

RESEARCH FACILITIES

SPECIAL FACILITIES

Tissue Culture and Histology Room

High Voltage Electron Microscope Room

Computer Room

Body Examination Room

LABORATORY OF EXPERIMENTAL ANIMALS

Terrestrial Animal Room

Aquatic Animal Room

INTERNATIONAL MEETINGS AND EXHIBITIONS IN THE FAR EAST

1984-1986

Compiled by Seikoh Sakiyama

The Australian Academy of Science, the Japan Convention Bureau, and the Science Council of Japan are the primary sources for this list. Readers are asked to notify us of any upcoming international meetings and exhibitions in the Far East which have not yet been included in this report.

1984

Date	Title	Site	For Information, contact
July 2-5	The 4th Office Automation Show	Tokyo, Japan	'84 OA Show Office Nihon Keizai Shimbun 1-9-5, Ohtemachi Chiyoda-ku, Tokyo 100
July 9-11	International Federation of Automatic Control (IFAS) System on Automation for Mineral Resource Development	Brisbane, Australia	Institute of Engineers Australia National Science Center 191 Royal Parade Parkville, Victoria 3052
July 9-13	The 5th International Symposium on Radio-pharmaceutical Chemistry	Tokyo, Japan	1984 Tokyo Symposium Office Business Center for Academic Societies of Japan 2-4-16, Yayoi, Bunkyo-ku Tokyo 113
July 9-14	The 4th International Drying Symposium	Kyoto, Japan	Dr. Ryozo Toei The Society of Chemical Engineers, Japan 4-6-19, Kobinata Bunkyo-ku, Tokyo 112
July 22-August 1	International Symposium on Marine Plankton	Shimizu, Japan	Mr. T. Kubota Marine Biological Center Tokyo University 1000, Orito, Shimizu Shizuoka 424
July 25-27	Hi-Tech '84 Osaka (Exhibition)	Osaka, Japan	Secretariat, Hi-Tech '83 c/o Marcom International, Inc. Akasaka-Omotemachi Building, Rm 705 4-8-19, Akasaka Minato-ku, Tokyo 107 (Application necessary)

Date	Title	Site	For information, contact
July 25-28	The 10th International Symposium on Nonlinear Acoustics	Kobe, Japan	Dr. Akira Nakamura, Chairman, The Institute of Scientific and Industrial Research Osaka University 8-1, Mihogaoka, Ibaraki Osaka 567
July 26-30	The 10th International Congress of Biometeorology	Tokyo, Japan	Dr. Hiroshi Inaba Juntendo Medical School 2-1-1 Hongo Bunkyo-ku, Tokyo 113
July (tentative)	'84 Microcomputer Show	Osaka, Japan	Japan Electronic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
July (tentative)	The 12th Conference International Cartographic Association	Perth, Australia	Mr. D. T. Pearce P.O. Box 6208 Hay Street East Perth, W.A. 6000
August 2-6	AUTOFACT Japan Conference and Exposition (rescheduled from April 1983)	Osaka, Japan	Nihon Keizai Shimbun 1-9-5, Ohtemachi Chiyoda-ku, Tokyo 100
August 2-6	MECHATRONICS '84	Osaka, Japan	Nihon Keizai Shimbun 1-9-5, Ohtemachi Chiyoda-ku, Tokyo 100
August 10-14	Australasian Institute of Mining and Metallurgy	Darwin, Australia	Australian Institute of Mining and Metallurgy P.O. Box 310 Carlton South, Victoria 3053
August 19-24	The 13th Congress of the International Commission for Optics	Sapporo, Japan	Professor S. Fujiwara Secretary of the ICO-13, Sapporo c/o Simul International Inc., Kowa Building 1-8-10, Akasaka Minato-ku, Tokyo 107

Date	Title	Site	For information, contact
August 20-24	The 7th IUPAC Conference on Physical Organic Chemistry	Auckland, New Zealand	The Secretary, Organizing Committee 7th IUPAC Department of Chemistry University of Auckland Private Bag, Auckland
August 20-24	National Conference and Exhibition on Robotics	Melbourne, Australia	Conference Department Institute of Engineers, Australia 11 National Court Barton A.C.T. 2600
August 22-30	Australian Academy of Science The 5th International Congress on Mathematical Education	Adelaide, Australia	Dr. J. Gaffney Wattle Park Teachers Court Kensington Road Wattle Park, S.A. 5066
August 26-31	The 3rd International Congress on Cell Biology	Kyoto or Kobe, Japan	Japan Society for Cell Biology Shigei Medical Research Institute 2117 Yamada Okayama 701-02
August 26-September 1	International Conference on the Photochemical Conversion and Storage of Solar Energy	Osaka, Japan	The Society of Kinki Chemical Industry 1-8-4, Utsubo-hommachi Nishi-ku, Osaka 550
August 27-31	Shiga Conference '84 on Conservation Management of World Lake Environment	Otsu, Japan	Department of Civil Life and Environment Shiga Prefectural Government 4-1-1, Kyomachi, Otsu Shiga 550
August 27-September 1	The 9th International Conference on Raman Spectroscopy	Tokyo, Japan	Professor M. Tasumi Department of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113

Date	Title	Site	For information, contact
August 28-September 3	Chinatech '84 - International Tool and Manufacturing Engineering Exhibition and Conference	Shanghai, People's Republic of China	Mr. Akram Yunas Exposition Department Society of Manufacturing Engineers (SME) 1 SME Drive, P.O. Box 930 Dearborn, MI 48121 U.S.A.
August 29-31	The 9th Australian Conference on the Mechanics of Structures and Materials	Sydney, Australia	Dr. P. Ansourian Conference Secretary ACMSM9, School of Civil and Mining Engineering University of Sydney Sydney, N.S.W. 2006
August (tentative)	Symposium on Asparagus Production	Tainan, Taiwan	Dr. Selleck Asian Vegetable Research and Development Center P.O. Box 42 Shanhua Tainan 741
August (tentative)	'84 Home Mechatronics Show	Osaka, Japan	'84 Home Mechatronics Show Office Nihon Keizai Shimbun Company, Ltd. 1-1, Maenocho, Kyobashi Higashi-ku, Osaka 5140
August (tentative)	International Micrographic Conference	Singapore	Dr. Teo Seng-kwee Singapore Micrographic Society 17-18 Lewin Terrace Singapore 0617
September 1-7	The 6th International Congress of Virology	Sendai, Japan	Professor T. Ebina Department of Bacteriology, Medical School Tohoku University 2-1, Seiryo-cho Sendai, Miyagi 980
September 2-6	International Symposium on Growth and Differentiation of Cells in Defined Environment	Fukuoka, Japan	ISGDCDE Secretariat Japan Convention Service, Inc. Nippon Press Center Building 2-1, 2-chome, Uchisaiwai-cho Chiyoda-ku, Tokyo 100

1984 Continued

Date	Title	Site	For information, contact
September 2-7	International Symposium on Snow and Ice Processes at the Earth's Surface	Sapporo, Japan	The Institute of Low Temperature Science Hokkaido University 8-chome, Kita 19-Jyo Kita-ku, Sapporo 060
September 2-8	The XIIth International Biometric Conference	Tokyo, Japan	Dr. T. Okuno Department of Mathematical Engineering and Instrumentation Physics Faculty of Engineering Tokyo University 7-3-1, Hongo Bunkyo-ku, Tokyo 113
September 3-7	The 1st International Conference on Technology of Plasticity	Tokyo, Japan	Japan Society for Technology Plasticity Torikatsu Building, 3F 5-2-5, Roppongi Minato-ku, Tokyo 106
September 3-7	The 9th International Symposium on Neurosecretion	Fuji, Japan	Professor S. Ishii Department of Biology School of Education Waseda University Nishi-Waseda Shinjuku-ku, Tokyo 160
September 3-7	1984 International Symposium on Glass in Connection with the Annual Meeting of the International Commission on Glass	Beijing, People's Republic of China	Professor Gan Fuxi Shanghai Institute of Optics and Fine Mechanics P.O.B. 8211 Shanghai, People's Republic of China
September 4-11	Weld Expo China '84 International Welding Exposition and Conference	Shanghai, People's Republic of China	AVP Expositions Company, Ltd. G.P.O. Box 12217 Hong Kong
September 6-11	International Conference on Quality and Reliability in Welding	Hangzhou, People's Republic of China	Secretariat of the Welding Institution of the Chinese Mechanical Engineering Society 65 He Xing Lu, Harbin

Date	Title	Site	For information, contact
September 8-10	The 3rd International Conference on Rotary Metalworking Processes - ROMP3	Kyoto, Japan	Professor M. Kobayashi Chairman, ROMP3 Department of Mechanical Engineering Technological University of Nagaoka Nagaoka 949-54
September 9-14	The 7th International Symposium on Organic Chemistry	Kyoto, Japan	Professor Makoto Kumada Chemical Society of Japan 1-5, Kanda-surugadai Chiyoda-ku, Tokyo 101
September 10-15	The VII International Symposium on Organo-silicon Chemistry	Kyoto, Japan	Dr. Makoto Kumata Faculty of Engineering Kyoto University Yoshida-Honcho Sakyo-ku, Kyoto 606
September 11-14	The 10th International Conference of IMEKO TC-3 on Measurement of Force and Mass (Internatrional Measurement Confederation)	Kobe, Japan	Professor T. Ono Department of Mechanical Engineering College of Technology University of Osaka 4-804, Ume-machi, Mozu Sakai, Osaka 591
September 19-22	IATSS Symposium on Traffic Science 1984	Tokyo, Japan	Internatioal Association of Traffic and Safety Sciences 2-6-20, Yaesu Chuo-ku, Tokyo 104
September 25-29	'84 Tokyo Industrial and Engineering Exhibition '84 Tokyo Engineering Design Efficiency Exhibition '84 Tokyo Automatic Control and Instrumentation Exhibition '84 Tokyo Automatic and Labor-saving Machines Exhibition '84 Computer Graphic System Show	Tokyo, Japan	The Industrial Daily News 1-8-10, Kudan-Kita Chiyoda-ku, Tokyo 102

1984 Continued

Date	Title	Site	For information, contact
September (tentative)	'84 Fluid Power International Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
October 1-6	The 3rd Asian Pacific Regional Astronomy Meeting of IAU	Tokyo, Japan	Professor T. Kogure Department of Astronomy Faculty of Science University of Kyoto Sakyo-ku, Kyoto 606
October 1-7	Pacific Region Wood Anatomy Conference	Tsukuba, Japan	P.O. Box 16 Tsukuba Agricultural and Forestry Research Institutes Ibaraki 305
October 3-6	The 11th Measuring Instruments Exhibition	Tokyo, Japan	Japan Measuring Instruments Federation 25-1, Nandocho Shinjuku-ku, Tokyo 162
October 4-9	'84 Japan Electronics Show	Tokyo, Japan	Japan Electronics Show Association c/o Tokyo Chamber of Commerce and Industry 3-2-2, Marunouchi Chiyoda-ku, Tokyo 100
October 7-12	The XVIIth International Congress of Internal Medicine	Kyoto, Japan	The Japan Society of Internal Medicine Hongo Daiichi Building, 8F 3-34-3, Hongo Bunkyo-ku, Tokyo 113
October 14-20	Conference on Mineral Processing and Extractive Metallurgy	Kunming, People's Republic of China	Nie Zhong Yong, Director Chinese Academy of Sciences Scientific and Technical Information Institute Beijing
October 15-19	Powder Industry '84 Exhibition	Tokyo, Japan	Powder Industry Office Nihon Noritsu Kyokai 3-1-22, Shibakoen Minato-ku, Tokyo 105

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Date	Title	Site	For information, contact
October 16-18	1984 International Symposium on Electromagnetic Compatibility (EMC)	Tokyo, Japan	Professor T. Takagi Department of Electrical Communications Faculty of Engineering Tohoku University Sendai, Miyagi 980
October 17-18	NRDO Conference 1984 (National Research Development Organiz-tion)	Kyoto, Japan	New Technology Development Organization 2-5-2, Nagata-cho Chiyoda-ku, Tokyo 100
October 22-26	The 9th International Conference on Infrared and Millmeter Waves	Takarazuka, Japan	Dr. H. Yoshinaga Department of Applied Physics Osaka University Yamadaoka, Suita Osaka 565
October 22-26	The 10th Annual International Conference on Industrial Electronics, Control and Instrumentation (IECON '84)	Tokyo, Japan	Professor H. Hanada IEEE-IES Electrical Engineering Departmment Kobe University Nada-ku, Kobe 657
October 30-November 2	The 7th International Conference on Computer Communication (ICCC '84)	Sydney, Australia	Dr. R. Cook Overseas Telecommunications 32-36 Marine Place Sydney, N.S.W. 2000
October 30-November 1	1984 Transport Conference Bulk Transport; Solid, Liquid, or gas	Perth, Australia	Conference Department The Institute of Engineers, Australia 11 National Court Barton A.C.T. 2600
Octobver 30-November 3	International Council for Computer Communication Convention	Sydney, Australia	Dr. R. Cook Overseas Telecommunications 32-36 Marine Place Sydney, N.S.W. 2000
October 30-November 8	The 12th Japan International Machine Tool Fair	Tokyo, Japan	Osaka International Trade Fair Commission c/o International Hotel 58, Hashizume-cho Uchi-Hommachi Higashi-ku, Osaka 540

1984 Continued

Date	Title	Site	For information, contact
October (tentative)	The 12th NECA Technical Fair	Tokyo, Japan	Nihon Electric Control Equipment Industry Association Daimon Hikari Building 2-1-18, Hamamatsucho Minato-ku, Tokyo 150
October (tentative)	Software Show '84	Tokyo, Japan	Japan Software Industry Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
October (tentative)	1984 Japan Machinery Fair	Nagoya, Japan	Nagoya-shi Mihon-ichi Kyokai 2-6-3, Fukiage Chikusaku, Nagoya 464
October (tentative)	Data Show '84	Tokyo, Japan	Japan Electronic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
October (tentative)	'84 Vacuum General Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
October (tentative)	'84 Osaka International Environment Preserving Machinery and Equipment Exhibition '84 Resources Recycling Technology and Energy Saving Instrument Exhibition '84 Osaka Physical Distribution and Materials Handling Exhibition '84 Robot and Automation Equipment Fair	Osaka, Japan	The Nihon Kogyo Shimbun Company, Ltd. 2-4-9, Umeda Kita-ku, Osaka 530

1984 Continued

Date	Title	Site	For information, contact
October (tentative)	Institute of Engineers Electric Energy Conference	Perth, Australia	Dr. J. Sullivan Science House 712 Murray Street Perth, W.A. 6000
November 12-15	The Second International Conference on Electrostatic Precipitation	Kyoto, Japan	Professor Senichi Masuda Chairman, The Institute of Electrostatics Japan Sharumu 80 Building, 4 F 4-1-3, Hongo, Bunkyo-ku Tokyo 113
November 19-23	The 12th World Mining Congress	New Delhi, India	Organizing Secretary 12th World Mining Congress The Institution of Engineers, India 8 Gokhale Road Calcutta 700020
November 20-22	AIM International Conference on Advances in Manufacturing. (Held in conjunction with Metalasia 84 and Automasia 84)	Singapore	Conference Director AIM-IFS Conference 35-39 High Street Kempston Bedford MK2 7BT, U.K.
November 21-28	International Mining Machinery Exhibition. (Held in association with 12th World Mining Congress)	New Delhi, India	Mining, Geological and Metallurgical Institute of India 29 Jawaharlal Nehru Road Calcutta 700016
November 22-23	Technology: Past, Present, and Future	Melbourne, Australia	Executive Officer Australian Academy of Technological Sciences Clunies Ross House 191 Royal Parade Parkville, Victoria 3052
November 26-30	Scientific Committee on Solar-Terrestrial Physics and Committee on Space Research, International Map Symposium	Kyoto, Japan	Professor S. Kato Kyoto University Yoshida-honcho Sakyo-ku, Kyoto 606

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Date	Title	Site	For information, contact
November (tentative)	The 7th International Hospital Engineering EXHIBITION (Hospex Japan '84)	Tokyo, Japan	Japan Management Association Kyoritsu Building 3-1-22, Shiba-Koen Minato-ku, Tokyo 105
November (tentative)	'84 Japan Education Materials Exhibition	Undecided, Japan	Japan Association of Manufacturers and Distributors of Educational Materials 1-17-1, Toranomon Minato-ku, Tokyo 105
November (tentative)	Microsystem Show '84	Tokyo, Japan	Japan Microphotography Association Daini Okochi Building 1-9-15, Kajicho Chiyoda-ku, Tokyo 101
November (tentative)	The 19th Exhibition and Conference of New Electrical Insulating Materials	Tokyo, Japan	Japan Electrical Insulation Materials Association Iwao Building 1-16-2, Toranomon Minato-ku, Tokyo 105
November (tentative)	The 23rd Analytical Instruments Show	Tokyo, Japan	Japan Analytical Instruments Manufacturers Taimei Building 3-22, Kanda-Ogawa-cho Chiyoda-ku, Tokyo 100
November (tentative)	'84 Optoelectronic Industry and Technology Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
November (tentative)	International Union of Pure and Applied Chemistry, The 7th International Biotechnology Symposium	New Delhi, India	Dr. M. Williams Bank Court Chambers 2-3 Pound Way Cowley Center Oxford OX4 3YF U.K.
December 3-5	Semicon Japan '84 (Semiconductors)	Tokyo, Japan	Secretariat, Semicon Japan '83 c/o Marcom International Inc. Akasaka-Omotemachi Building, Rm 705 4-8029, Akasaka Minato-ku, Tokyo 107

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Date	Title	Site	For information, contact
December 4-10	The 6th International Conference on Fracture	New Delhi, India	Dr. Raju Deputy Director National Aeronautical Laboratory Bangalore 560017
Undecided	International Association of Hydrological Science on Groundwater	Undecided, Australia	Dr. J. C. Rodda Water Data Unit Reading Bridge House Reading RG1 8PS U.K.
Undecided	The 3rd Asia and Oceania Conference of Nuclear Medicine	Seoul, Korea	Korean Society of Nuclear Medicine 28 Ueong-dong Chongo-ku, Seoul
Undecided	Asian-Australian Association of Animal Production/Animal Science Societies	Seoul, Korea	Department of Animal Science College of Agriculture Seoul National University 103 Seodon-dong Suwon City, (Konggi)
Undecided	International Federation of Society for Electron Microscopy Asian Pacific Electron Microscopy Congress	Singapore	Department of Material Science and Engineering 280 Hearst Mining Building Berkeley, CA 94720 U.S.A.

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Date	Title	Site	For information, contact
January 14-15	Automation Asia '85 Instrument Society of America and Society of Manufacturing Engineers Floating Exhibition	Seoul, South Korea	Exhibits Development Manager, SME 1 SME Drive P.O. Box 930 Dearborn MI 48121 U.S.A.
February 11-14	Polymer 85: Characterization and Analysis of Polymers. International Polymer Symposium	Melbourne, Australia	Polymer 85, Royal Australian Chemical Institute 191 Royal Parade Parkville, Victoria 3052

1985 Continued

Date	Title	Site	For information, contact
February 11-16	The 2nd Asian Mining Conference and Exhibition (Rescheduled from 5-8 November 1984)	Manila, Philippines	Conference Office Institution of Mining and Metallurgy 44 Portland Place London W1N 4BR U.K.
February (tentative)	The 5th International Congress of Pacific Science Association	Bakguio, Philippines	Dr. Paulo Campos National Research Council of the Philippines Gen Santos Avenue Bicutan, Taguig Metro Manila
March (tentative)	Annual National Conference of the Institution of Engineers, Australia	Melbourne, Australia	LtCol. J.A. McDonald Secretary, Victoria Division Institute of Engineers, Australia National Science Center 191 Royal Parade Parkville, Victoria 3052
April 2-6	Wire Tokyo 85: The 2nd International Wire Exhibition	Tokyo, Japan	Dr. Frank Hodgson Director of Public Relations Mack-Brooks Exhibitions 62 Victoria Street St. Albans AL1 3XT U.K.
April 15-19	Eighth Australian Symposium on Analytical Chemistry	Melbourne, Australia	Eighth ASAC G.P.O. Box 1929 Canberra A.C.T. 2601
May 11-16	The 13th Congress of the Council of Mining and Metallurgical Institutions	Canberra, Australia	Council of Mining and Metallurgical Institutions 44 Portland Place London W1N 4BR U.K.
May 20-24	The 3rd Conference on Steel Development	Melbourne, Australia	Australian Institute of Steel Construction P.O. Box 434 Milsons Point, N.S.W. 2061
July 14-20	The 6th International Congress for Ultrasound in Medicine and Biology	Sydney, Australia	Dr. R. Jellins P.O. Box R374 Royal Exchange Sydney, N.S.W. 2000

1985 Continued

Date	Title	Site	For information, contact
August 12-16	The 6th International Meeting on Ferroelectricity	Kobe, Japan	Professor S. Nomura Physical Electronics Faculty of Engineering Tokyo Institute of Technology Meguro-ku, Tokyo 152
August 18-23	The 8th International Conference on Chemical Education	Tokyo, Japan	The Chemical Society of Japan 1-5, Kanda-Surugadai Chiyoda-ku, Tokyo 101
August 19-24	1985 International Symposium on Lepton and Photon Interactions at High Energies	Kyoto, Japan	Research Institute for Fundamental Physics Kyoto University Oiwake-cho, Kita-shirakawa Sakyo-ku, Kyoto 606
August 19-30	The 23rd General Assembly of IASDPEI (International Association of Semismology and Physics of the Earth's Interior)	Tokyo, Japan	Intergroup Corporation Akasaka Yamakatsu Building 8-5-32, Akasaka Minato-ku, Tokyo 107
August 26-30	The 6th International Symposium on Polarization Phenomena in Nuclear Physics	Osaka, Japan	Professor M. Kondo Research Center of Nuclear Physics Osaka University Yamadaoka, Suita Osaka, 530
August (tentative)	Coastal Engineering Conference	Melbourne, Australia	The Conference Manager Australia The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	International Association Hydraulic Resources Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	The 21st Congress for IAHR (International Association for Hydraulic Research)	Melbourne, Australia	Mr. Robin Vickery Institute of Engineers Australia 11 National Circuit Barton, A.C.T. 2600

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Date	Title	Site	For information, contact
August (tentative)	The 8th IUPAC Conference on Physical Organic Chemistry	Tokyo, Japan	Professor M. Oki Department of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo, Bunkyo-klu Tokyo 112
September 4-11	The 11th International Teletraffic Congress ITC-11	Kyoto, Japan	ITC-11 Committee Musashino Electrical Communication Laboratory 3-9-11, Midorimachi Musashino, Tokyo 180
September 6-10	1985 Annual Conference of the IIC (International Institute of Communications)	Tokyo, Japan	International Relations Department Japan Broadcasting Corporation 2-2-1, Jinnan Shibuya-ku, Tokyo 150
September 10-13	The 3rd International Cell Culture Congress	Sendai, Japan	Professor S. Yamane Research Institute for Tuberculosis and Cancer Tohoku University 4-1, Seiko-cho Sendai, Miyagi 980
September 21-25	World Congress III of Chemical Engineering	Tokyo, Japan	Secretariat, the Society of Chemical Engineers Kyritsu Building 6-19, Kohinata 4-chome Bunkyo-ku, Tokyo 112
October 15-18	International Rubber Conference	Kyoto, Japan	The Society of Rubber Industry, Japan Tobu Building 1-5-26, Motoakasaka Minato-ku, Tokyo 107

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Date	Title	Site	For information, contact
March 16-21	The 10th International Congress of Prestressed Concrete	New Delhi, India	Mr. C. R. Alimchandani Stup Consultants, Ltd. 1004-5-7, Raheja Chambers 213 Nariman Point Bomblay 420-021

1986

Date	Title	Site	For information, contact
May 11-17	Congress of the International Society of Haematology and the International Society of Blood Transfusions	Sydney, Australia	Dr. I. Cooper, President Haematology Society of Australia Cancer Institute 481 Little Londsdale Street Melbourne, Victoria 3001
July (tentative)	International Institute of Welding Annual Assembly 1986	Tokyo, Japan	Japan Welding Society 10-11, Kanda-Sakumacho Chiyoda-ku, Tokyo 101
August 25-29	The 12th International Congress of the International Association of Sedimentologists	Canberra, Australia	Professor K.A.W. Crook Department of Geology Australian National University P.O. Box 4 Canberra, A.C.T. 2600
August 26-30	International Conference on Martensitic Transformations (ICOMAT-86) in Commemoration of JIM 50th Anniversary	Nara, Japan	ICOMAT-86 The Japan Institute of Metals (JIM) Aoba, Aramaki Sendai 980
August (tentative)	The 7th World Congress on Air Quality	Sydney, Australia	Mr. K. Sullivan Clean Air Society of Australia and New Zealand P.O. Box 191 Eastwood, N.S.W.
September 21-25	The World Congress of Chemical Engineering	Tokyo, Japan	The Society of Chemical Engineers, Japan Japan Kyoritsu Kaikan 4-6-19, Honhinata Bunkyo-ku, Tokyo 112
September (tentative)	The 8th International Congress of Psychosomatic Obstetrics and Gynecology	Melbourne, Australia	Dr. L. Dennerstein Department of Psychiatry University of Melbourne c/o Royal Melbourne Hospital Parkville, Melbourne 3052
Undecided	International Microbiological Congress	Perth, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601

* U.S. GOVERNMENT PRINTING OFFICE: 1984-443-660